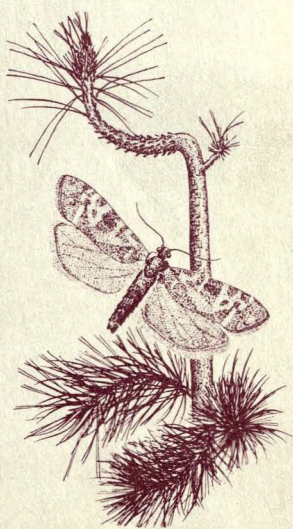




ANNUAL REPORT 1962



*Northeastern Forest
Experiment Station*



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IN GENERAL

A MILLION dollars doesn't seem very much in comparison with the defense program, the national debt, or even the ransom paid for the Cuban prisoners. And it doesn't buy as much new construction as it used to. But when you have it for constructing new research facilities—and it's your first million—it seems terribly important. It has kept us on our toes this past year to meet deadlines with architects, engineers, and builders and to make sure the construction program moves forward.

Construction and Public Works

And it has moved. The small office/laboratory building at Hubbard Brook Experimental Forest at West Thornton, N.J., has been completed, and good progress is being made on construction of our Forest Products Marketing Laboratory at Princeton, W. Va. Architects have been selected and are drafting plans for the Forest Recreation and Wildlife Laboratory at Warren, Pa., the Timber and Watershed Laboratory at Parsons, W. Va., and the Methods Laboratory building on the experimental wood yard at Princeton, W. Va. We are even encouraged to dream about a new Station headquarters building in the Philadelphia suburbs!

Participation in the Accelerated Public Works Program has also contributed to our research facilities. It has enabled us to surface some of the truck roads on the Fernow Experimental Forest at Parsons, W. Va. It has enabled us to prepare the Buckaloons recreation area at Warren, Pa., for better service to the public and for continued studies in our program of recreation research that is centered there.

Personnel

As recently as 2 years ago, as the result of transfers and retirements, only two of our seven division-chief positions were filled. As they became eligible for advancement, Warren Doolittle (Forest Management), Robert Bain (Station Management), Adrian Gilbert (Economics), and William Waters (Insects) have been promoted to fill these vacancies.

To enable our staff of scientists and administrators to acquire greater competence, we are continuing a broad training program. In addition to the ever-important on-the-job learning, we have offered

training courses in statistics, log grading, writing, and electronic data processing. We are also taking advantage to the fullest extent possible of outside opportunities for training. Six men are spending a full year doing specialized graduate work at Wisconsin, Duke, Michigan, Penn State, and Yale Universities. Sixteen others have been assisted under the Training Act (P.L. 85-507) in taking short courses offered by different agencies and institutions. And several others are taking correspondence and night-school courses at their own expense.

The Forestry Schools

Our ties with the forestry schools in the Northeast have always been close and are drawing even closer, as they should. We recruit many of our scientists from these institutions, and depend on the schools for the advanced training of our personnel in graduate study. Close association with the faculties stimulates new ideas and approaches to our research effort. All the accredited schools are represented on our Research Advisory Committee. We have found that our respective research programs can also be strengthened through cooperative studies; and cooperative agreements with all the forestry schools and with some other schools and departments are now in effect.

Our physical ties with the forestry schools are not as close as in some other regions, but are being drawn closer. We now share physical facilities with Yale University, New York State University, and the University of Vermont; and our Bangor unit will move to the campus of the University of Maine this spring. Other similar moves are in the negotiation or planning stage.

So we are understandably pleased when the faculties, the instruction programs, the research programs, and the physical plants of the forestry schools are improved. So much improvement is taking place these days that it seems this minor revolution should be reported in broad outline.

The forestry schools and departments who have not shared very fully in the Hatch Act funds at the Land-Grant Colleges have gained new hope from the passage, by the last session of Congress, of the so-called McIntire-Stennis bill (P.L. 87-788). This Act authorizes Federal payments to the States on a matching basis for forestry research. The President's budget this year carries an appropriation item of \$1,000,000 to get the program started. Within the Department of Agriculture, the Act will be administered by the Cooperative State Experiment Station Service.

Something like 25 percent of all undergraduates in accredited

forestry schools are enrolled in universities in the Northeast. Undergraduate enrollment continues to increase, though at a slower rate than in the early '50s.

Enrollment in graduate schools, on the other hand, is increasing rapidly. The School of Forestry at Yale and the New York State College of Forestry at Syracuse, with a combined total of some 240 graduate students, have long led in this field. But every forestry school in the Northeast is now offering or definitely planning for graduate instruction. Three of the schools are developing graduate programs while minimizing or abandoning undergraduate instruction.

The Ranger School of the New York State College of Forestry now enters its 51st year with a 2-year program for forestry technicians. And Penn State will also offer a 2-year program at its Mont Alto campus commencing next year. On the other hand, the University of Massachusetts is dropping its forestry technician program.

A uniform trend among the schools is an increased emphasis on research and strengthening of faculties, an accompaniment to the expanding programs of graduate study. The Ph. D. degree is commonly a requirement for permanent tenure for younger faculty members. Many more fellowships and scholarships are being offered to enable brilliant young men to receive graduate training and research experience. Many private individuals, foundations, and associations are supporting these scholarships; and outside support of research is also increasing.

As enrollments increase, as faculties grow in size and in scientific sophistication, and as research programs expand, a common need arises for new structures and new equipment. Accordingly, every forestry school in the Northeast has either improved and expanded its physical plant in recent years or has funds and plans to do so soon. Some of these improvements are relatively modest; others run into the millions of dollars. And new scientific equipment is being installed in the new laboratories. Electronic computers are so commonplace that they have lost their importance as status symbols.

Curricula are being revised to introduce new fields of instruction, to permit more specialization, and to accommodate aptitudes and interests of students. Penn State, for example, offers science and technology options in its baccalaureate program. Yale has introduced a new area of study in forest science in its graduate school. Economics, wildlife, and utilization seem to be the specialties favored in several curriculum revisions.

More specialized short courses, seminars, and conferences are being held for the purpose of exchanging information and of providing refresher courses for practicing foresters and researchers.

Several of the schools have continuing cooperative relations with other countries. For example, the N. Y. State College of Forestry cooperated last summer with a 12-week program in tropical forestry presented in Puerto Rico, and continues its cooperative program with the University of the Philippines. West Virginia University has cooperative programs with Tanganyika. Other faculty members travel, study, and instruct in foreign schools.

These developments, and many more that could not be reported here, for reasons of space, demonstrate how well our forestry schools are aware of changing conditions, new opportunities, new responsibilities, and the steps that must be taken to meet these new challenges. We pledge them our continued support.



FOREST MANAGEMENT

THE year 1962 turned out to be a time of many changes in this Division's programs, personnel, and operations. During the year we prepared 14 new line-project plans: 10 in forest management, 2 in recreation research, and 1 each in wildlife habitat and fire research. These new projects implement the Station's reorganization of its research program, which now places more emphasis on projects of narrower scope and on intensification of effort on each problem. Among other changes, the terms Research Center and Research Center Leader have been replaced by Project and Project Leader. Following are the projects and their locations:

Silviculture of spruce and associated hardwoods—Orono, Maine.

Improvement of sugar maple for sap production—Burlington, Vt.

Planting and seeding of northern hardwoods—Burlington, Vt.

Silviculture of beech-birch-maple type in the Northeast—Laconia, N.H.

Silviculture of eastern white pine, including tree improvement—Alfred, Maine.

Silviculture of Allegheny hardwoods, including animal damage—Warren, Pa.

Genetic improvement of coniferous and hardwood species for timber production in the Northeastern Region—Chestnut Hill, Pa.

Silviculture of northern Coastal Plain and Piedmont forests of the Northeast—New Lisbon, N.J.

Silviculture of northern Appalachian hardwoods—Parsons, W. Va.

Mensuration studies of northeastern forest species and types—Upper Darby, Pa.

Development of improved guides to fire control planning and action programs adapted to the fuels and climate of the Northeastern States—Upper Darby, Pa.

Planning, improving, protecting, and managing forest recreation—Warren, Pa.

Wildlife habitat management in northeastern forests, including rehabilitation and improvement of single-use rights-of-way—Warren, Pa.

Cooperative forest recreation project with New York State College of Forestry—Syracuse, N.Y.

In our report this year it has not been possible to cover all of the progress and results accomplished in 1962, but we have tried to include the most important and interesting items in fire, wildlife,

recreation, and silviculture. In silviculture we have two special sections on silvicides and coal mining spoils and a third section, "other results," which consists of short summaries of results of other silvicultural studies made during the year. Several items of general interest bear mention briefly here before we present research progress and results:

- The Fish and Wildlife Service of the Department of Interior recently posted Ward Sharp at Warren, Pa., to conduct wildlife research in cooperation with the Station.
- The Accelerated Public Works program of late 1962 was helpful in getting certain construction work accomplished at Warren, Pa., and Parsons, W. Va. This construction was in support of going research programs at both locations; it included roads, certain types of buildings, and recreation facilities.
- John Bjorkbom, at Orono, Maine, completed a problem analysis for the regeneration of paper birch. This analysis covers problems in both natural and artificial regeneration. Most of the work on paper birch completed or planned so far has been on site preparation for natural regeneration and on seedfall and seed dissemination.
- Our Alfred, Maine, white pine project was revised recently to put more emphasis on the genetic improvement of white pine for weevil resistance and silvicultural methods for control of the white-pine weevil. Other major problems retained in the project include direct seeding and the silviculture of young stands.

FIRE RESEARCH

After a 2½-year lapse, our fire-research project was reactivated in May when Wayne Banks returned to the Station from an ICA assignment. Since his return, Banks' efforts have been directed largely toward completion of several papers previously in progress and to planning for several new high-priority studies.

Fire Weather Classification

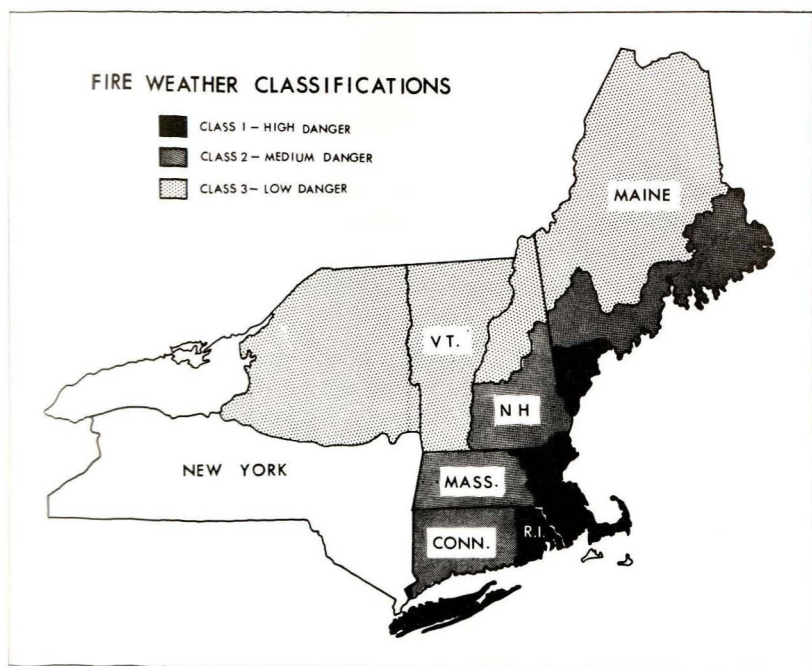
During the fire season, burning indexes are computed daily from data collected at fire-weather stations throughout the Northeast. From these records, three classes of weather—in respect to fire danger—have been developed for New England and New York. These classes are based on the average annual number of days with a burning index of 25+, 40+, and 60+. Following are the specifications for these three fire-weather classifications, in minimum number of days per year:

<i>Danger class</i>	<i>Burning Index</i>		
	25+	40+	60+
High	60	30	12
Medium	40	20	8
Low	20	10	4

The locations of areas according to fire-weather classifications have been mapped for New England and New York. As might be expected, this classification shows that the high-danger areas are restricted primarily to the Coastal Plain.

Rate of Spread

In cooperation with Region 7 of the U.S. Forest Service, the rate of spread of fires was studied in relation to the burning index on the Type 8 danger meter. One set of relationships was based on 1,575 fires that occurred in Region 7 in 1950-58, and another set was based on the fastest-spreading 25 percent of these fires. Although it is obvious that the rate of spread for the fastest-spreading 25



A new fire-weather classification for areas in New England and New York. As might be expected, the high-danger zones are mainly in the Coastal Plain.

percent of fires would be greater than for all fires, special note should be made of the fact that the increase in rate of spread—as the burning index increases—is also greater for the fastest-spreading 25 percent of fires. However, there appears to be good correlation of burning index to rate of spread for both sets of fire data.

Causes of Forest Fires

It is natural to expect that there would be some range of differences in the causes of fires among the various parts of the Northeast. This could be attributed to differences in fuels, characteristics of the people, use of forested areas, weather, and other related factors. However, the magnitude of the range of these differences in reported causes appears to be greater than would normally be expected. For example, in 1961 the percentage of forest fires reported by states in the Northeast showed a range as follows for several of the more important causes of fire:

<i>Cause of fire</i>	<i>Range in percentage of fires reported</i>
Smoking	1 — 62
Debris burning	10 — 43
Incendiary	4 — 60
Miscellaneous	4 — 41
Campfires	1 — 23
Railroad	3 — 21
Lightning	0 — 19

The Station is planning to make an intensive study of at least a portion of the fires in 1963. The primary purpose of this study will be to determine with certainty the cause of each fire investigated, and to obtain detailed information on the individual or factor responsible. Region 7 and several states will be approached for close cooperation in this work.

WILDLIFE HABITAT

During the past year, a preliminary plan was completed for the wildlife-habitat research program at Warren, Pa. Five problems are recognized in this plan: (1) techniques and methods of habitat management, (2) wildlife-timber relations, (3) special practices for habitat improvement, (4) ecology, physiology, and nutritional value of wildlife plants, and (5) wildlife valuation.

More and more evidence points to the importance of wildlife-timber relations—both in research and in practice. It is well known that timber-management practices generally improve the habitat for game—especially for deer. However, less well known are just how



Deer browse and/or timber. This stand of young Pocono Mountain hardwoods was cut back (to 45 square feet of basal area) to compare the effects of thinning on the production of deer browse and the volume and quality of timber.

the intensity of these practices is related to the quantity and quality of the improved habitat, and how long this improved condition will last. Since the management of forest land for the production of timber is so widely practiced, it is readily apparent that one of the greatest opportunities to improve wildlife habitat rests upon a better understanding of the relationships between timber and wildlife.

Cutting for Browse and Timber

The establishment of a cooperative study in wildlife-timber relations between the Pennsylvania Game Commission and Northeastern Station was reported last year. In 1962, the first measurements were made to compare the effects of five different cutting or thinning intensities on the production of deer browse in young northern hardwood stands.

As a result of these treatments, residual basal areas of 0, 15, 30, 45, and 60 square feet yielded 26, 24, 21, 17, and 11 pounds (green weight) of new sprout browse respectively during the first growing

season. Although these responses were not significantly different, it is likely that real differences will show up by the third and fourth year.

The treatment that left 60 square feet of basal area in pole-size hardwoods probably approaches the level of thinning and improvement cuttings required for good timber production. However, we anticipate the need for a choice among cutting intensities to meet local management objectives—probably with some compromise in the production of both timber and browse.

Response of Seedlings to Browsing

Seedlings of commercial tree species are an important source of deer browse in northern hardwood forests. Hence the successful regeneration of these species often is a problem common to both timber and wildlife management. The problem is readily recognized where deer browse the seedlings so severely that regeneration does not happen; but, more important, how much browsing can these seedlings tolerate and still continue to serve both as a source for browse and for future stand?

A study to determine this point in browsing intensity was started recently for black cherry, white ash, and sugar and red maple. Approximately 1,000 wild seedlings were transplanted to an old-field area, and eight clipping treatments were used to simulate various intensities of deer browsing. These treatments will be repeated over a 5-year period.

Results at the end of the first growing season showed that the initial clipping treatments did not increase mortality or reduce the height growth of seedlings, even after the removal of all of the past year's growth—the most severe treatment. The seedlings did show individual differences in the type of sprouting—even within the same treatment. For example, some seedlings produced a fast-growing sprout from the root collar when all current growth was clipped; others retained their original form and sprouted new growth from the upper, residual portions of the seedling. But here again the really significant differences in growth, form, and survival will probably not be certain until after 3 or 4 years of treatment.

Other Studies

A cooperative study is under way with the Pennsylvania Gas Company to determine the effect of a chemical fertilizer on the palatability of beech and striped maple sprouts to deer. Both of these tree species are ordinarily browsed sparingly by deer, except in areas of high deer population where both winter and spring use increases. Since these

two species are less valuable for timber, some biological control such as deer browsing—perhaps as stimulated by a fertilizer—should result in an improvement for both game and timber.

Another study, in cooperation with the New Jersey Bureau of Forestry, is being planned to seek the relationship between the production of browse (woody and herbaceous) and silvicultural practices in the Pine Region of New Jersey. The silvicultural practices include partial cutting and prescribed burning.

FOREST RECREATION

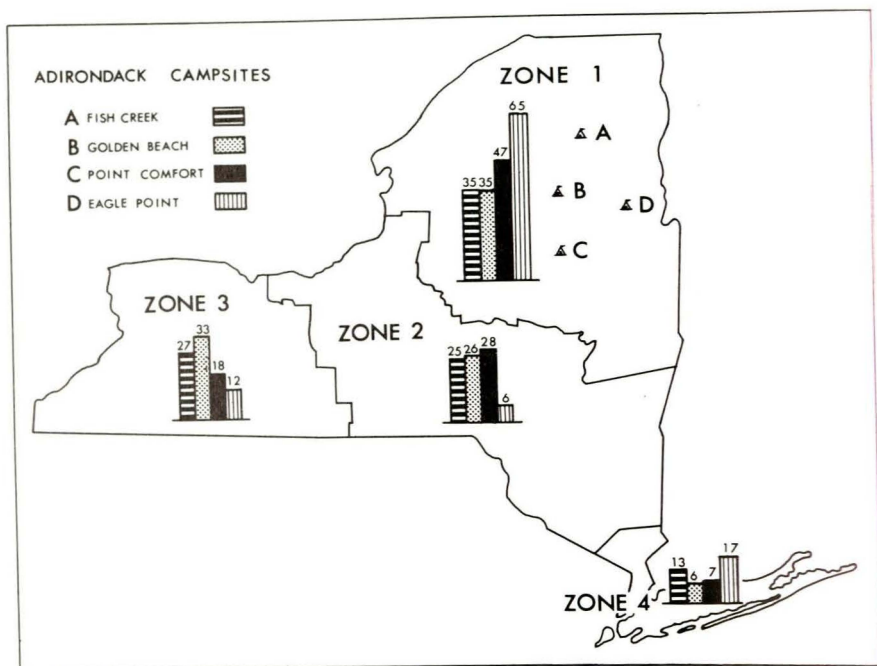
During the past year, two experienced members of the Warren Project departed for other research positions in the Forest Service: Alan Wagar transferred to the Intermountain Forest and Range Experiment Station at Logan, Utah; and Elwood L. Shafer, Jr. went to Syracuse, N.Y., where he is heading up a new cooperative research project in recreation between Northeastern Station and the New York State University College of Forestry. Naturally their leaving has been a disrupting factor in the work project; but we are heartened by the way our two new men, Wilbur LaPage and Roger Rich, are applying themselves to both old and new studies.

Cooperative Research at Syracuse

The cooperative recreation-research project at Syracuse will include individual and cooperative studies aimed at maintaining desirable woodland environment in recreation areas; establishing and maintaining scenic zones and woodland screens through restricted use and intensive management; developing new and more scientific methods and techniques for the administration and care of recreation areas; determining user reactions, attitudes, and demands; and correlating experimental results with forest-land management practices.

Study of Campsite Users

Both managers of recreation areas and legislators need to know more about the socio-economic characteristics of outdoor forest recreationists. For example, this information is needed to help in planning adequate camping facilities, for allocating costs, and for regulating fees to meet the increasing demand. It was with these needs in mind that a cooperative study was made last year in the Adirondack Forest Preserve by the New York State Conservation Department, the State of New York Joint Legislative Committee on Natural Resources, the New York State Income Tax Bureau, and the Northeastern Station.



Four campsites in the Adirondacks, and the distribution of visitors according to resident zones. The bars indicate percentages of visitors.

The specific objective of the study was to determine if visitors to public campsites in the Adirondacks differed because of income class or resident zone in New York State. Four campsites in the Adirondacks were involved: Fish Creek, Golden Beach, Point Comfort, and Eagle Point. Only heads of households from New York who visited the campsites in 1961 were sampled. Camping permits on these four campsites were sampled from the files of the Conservation Department, and the users were catalogued by the Tax Bureau into four income classes¹ and four resident zones.

Campsite use differed significantly according to resident zone of camping parties; but the number of camping parties by income classes were unrelated to campsite; or, in other words, income distribution was the same for all campsites. However, there was a significant

¹ Income classes were \$0 to \$3,999, \$4,000 to \$6,999, \$7,000 to \$9,999, and \$10,000+. These classes of camping parties were determined by the Tax Bureau, and no information that would identify the campers with their incomes was made available to the persons working on this study.

relationship between camper income and resident zone: the percentage of camping parties in the higher income group (\$7,000 +) increased as resident zone distance increased—and perhaps as population density of the zone increased.

Attitudes of Recreationists

Analysis has been completed on a study of attitudes and preferences of visitors at the Twin Lakes recreation area on the Allegheny National Forest in Pennsylvania and on the Stuart Recreation Area of the Monongahela National Forest in West Virginia. Results show that visitors to the two areas differ significantly in distributions of age, occupation, income, education, distance from home, reasons for visiting, number of visits, hours spent per visit, and the proportions who picnicked, sat and watched, or pursued some active recreation. In addition, some of the relationships found to be important on one area were found to be not important at the other area. Thus visitors to the two areas were sufficiently different in their attitudes that their actions on one area could not be predicted adequately from a questionnaire survey at the other area.

We also found that the extent to which people participated in any one activity was not an adequate description of their motivation. For example, at the Twin Lakes and Stuart recreation areas, respectively, 35 and 40 percent of the respondents included "sight-seeing" among their activities. However, when asked to give the main reason for attending the area, only about 1 and 4 percent of the respondents, respectively, mentioned scenery, sight-seeing, or related reasons.

There were also some patterns of agreement in the data between the two areas. This study was extended in the summer of 1962 to several Adirondack campgrounds in New York and to the Shawnee and Gifford Pinchot State Parks in Pennsylvania. The same questionnaires and methods were used, and the data are now being analyzed.

Mapping Use of Facilities

In 1960 the results of a preliminary study in mapping facilities seemed promising, and a definite preference for areas close to parking was found; but in a 1961 full-scale study on the White Mountain campgrounds, the mapping method did not prove to be a good tool at all for reflecting visitor preferences. There were several reasons for this. Crowding was most important because on congested campgrounds little or no choice is available. Length of tenure reduced the effectiveness of the mapping method on campgrounds, as compared to day-use areas; for example, a camper may use a site from 1 day to 2 weeks, whereas five different parties might choose a picnic

site in a single day. Uniformity of camp sites also tends to obscure and diminish the effects of visitor preferences. On each campground the tree cover, drainage, and other features were usually uniform; and standards for spacing of sites, water, toilets, and other facilities provided little choice even when crowding was not a factor.

In short, the 1961 portion of this study pointed out some of the difficulties in doing certain types of research on administrative operation areas. Partially as a result of these sampling problems, an experimental campground is now being constructed on the Irvine Demonstration Forest area adjacent to the site of our new Forest Recreation and Wildlife Laboratory. Several of the leads concerning visitors' preference for variations in facilities and forest environment will be examined further in more closely controlled studies on this area.

Irvine Demonstration Forest Area

The development of experimental facilities on the Buckaloons Recreation Area near the headquarters of the Warren project was given the boost needed by the new Accelerated Public Works program. A 40-unit campground was designed and installed; the old 10-unit campground was converted to a picnic area; old sub-standard toilets were replaced; a 6,100-foot interpretive trail with footbridges was installed; and other interpretive devices and signs are planned.

The Buckaloons Recreation Area has many advantages as a research area: it is designed to facilitate research, it can be closely supervised; and visitor registrations can be carefully recorded and checked daily. Several studies are being begun on the area: one to compare spur versus turnout type campsites and walk-in versus step-over tables; another to compare Forest Service elevated and ground-level fireplaces, and National Park Service (tilting type) elevated and ground-level fireplaces; two studies of plant and soil changes; and a study of eight species of wood, two thicknesses of plank, and two preservative treatments for use in constructing picnic tables.

Other Activities

At the close of the Outdoor Recreation Resources Review Commission's (ORRRC) studies, one set of IBM cards with inventory data was obtained. This set contains the inventory of sites and facilities for the 12 Northeastern States. These data are being analyzed for results in addition to those reported by the ORRRC. Although these data are now 2 to 3 years old, they will provide valuable material for research problems.

Another set of cards was obtained from the "on-site" studies made for the ORRRC by the Survey Research Center of Michigan State University. Additional analyses of these data are also being made on a regional basis. Seven of the 24 sites studied in the United States by the ORRRC were in the 12 Northeastern States within which this project conducts research.

SILVICIDES

In the oak—yellow-poplar and coastal oak-pine types of the Northeast, the more desirable, productive species do not reproduce themselves well under conditions of natural competition. If we are to achieve a high level of timber production in these types in the future, we must somehow regenerate the productive species.

On the best hardwood sites oaks, yellow-poplars or sweetgums will grow 75 to 95 feet tall in 50 years; but seedlings of these species are relatively intolerant, and other more tolerant, less valuable species tend to take over. These tolerant species, such as spicebush and red maple, may form thickets under mature canopies. Where little or no attempt is made to control reproduction after cutting, the undesired species usually form most of the succeeding stand. Similarly, in the oak-pine types the pine components usually are more valuable than the hardwoods that tend to replace them. In swamps, particularly of southern New Jersey, Atlantic white-cedar has long been a valuable species, while the more tolerant associated hardwoods have never been merchantable.

The problem of securing stands of productive species is even more acute in those areas where the desired species are scarce or absent—areas where hardwoods predominate on sites better adapted to conifers; or areas where maples, blackgums, hollies, and other low-value species occupy sites that should be growing yellow-poplar, sweetgum, or bottomland oaks. In some sections, stand composition has degenerated under wildfires to brushy scrub oaks.

In the past, relatively little could be done by way of manipulating reproduction and controlling stand composition. Hand methods with machete and ax were slow, costly, and not very effective; power-machine methods were not adaptable to many of the problem situations, and they too were costly. The picture now is changing. With herbicidal chemicals, effective control of reproduction and stand composition is becoming possible at acceptable costs.

Application and Uses

Modern silvicides and effective methods for applying them represent a major accomplishment by researchers in recent years for

reproducing existing stands and for rehabilitating deteriorated stands. Two of the application methods that are proving to be particularly useful in the coastal oak-pine and adjacent hardwood regions are: (1) individual-stem treatments in cut frills, used mostly on stems 2 inches or more in diameter; and (2) foliage treatments by mist-blower applications, used on relatively small hardwood growth.

Each method has several roles in the silviculture of our forests. Where the desired species are more resistant than the undesired ones, mist-blowing can be used in mixed reproduction for selective release—for the freeing of conifers from competing hardwoods. Similar selective release obviously is impossible where the desired species are hardwoods that are fully as susceptible to the chemicals as their unwanted associates. However, mist-blowing can be used in mature hardwood stands as a conditioning treatment—to eliminate dense understories of undesirable trees and shrubs and thus to prepare the site for reproduction before harvesting the overstory. It can, of course, be used similarly in mature pine stands. Mist-blowing also can be used as a first step in converting low-value hardwood stands of any age to better species.

Single-stem treatments are useful in various situations, either alone or as a follow-up after brushy understories have been reduced by mist-blowing or disking. Common uses of single-stem treatments alone are in weeding young hardwood stands, in releasing pines from competing hardwoods in mixed stands, and in releasing desirable reproduction from cull trees left after the last logging. As a follow-up after reduction of brushy understories, single-stem treatments can be applied to weed and cull trees in conditioning stands for regeneration just before a harvest cut, in weeding mixed hardwood-conifer stands, and in converting stands of poor composition to better species.

Contributions of Local Research

Both the role of silvicides and techniques for applying them in the above situations have been developed over the past 10 or 12 years by the Station and three cooperating State forestry departments—in Maryland, New Jersey, and Pennsylvania. As a result of cooperative research, the standard method since 1953 for killing individual stems of undesirable hardwoods in eastern Maryland has been application of 2,4,5-T in oil in ax-chopped frills.

However, the ax-frill method has been largely replaced in the South by the use of tree injectors, and considerable interest in injectors had developed in our region. Injectors ensure that the silvicide is applied near the base of the stems where it is most effective in



A chemical injector being used to kill an unwanted hardwood tree. This is one of the techniques included in silvicide studies under way in New Jersey and eastern Maryland.

reducing sprouting. Because results may be affected by many variables, such as species, season, regional climate, concentration and type of chemical, amount of material per cut, and type of injector, we did not feel we could recommend injector treatments in our region without local testing. Consequently, in 1961 we began a cooperative study to provide the desired locally based information. The study involved three geographic locations (eastern Maryland, northern and southern New Jersey), two materials, three concentrations, and four seasons. All treatments were made with a locally manufactured injector. First-year results were presented at the 1963 Northeastern Weed Control Conference.² The more important findings are as follows:

- Spring treatments are most effective and winter treatments least effective. However, good kills can be obtained in winter if treatments are carefully done; that is, by making complete frills and applying the full specified dosage in each injector cut.
- 2,4,5-T amine dilutions (in water) are effective on susceptible species, especially oaks; but they are less effective than 2,4,5-T

² Little, S. Injector treatments for killing New Jersey and eastern Maryland hardwoods. Northeast. Weed Control Conf. Proc. 17: 494-501. 1963.

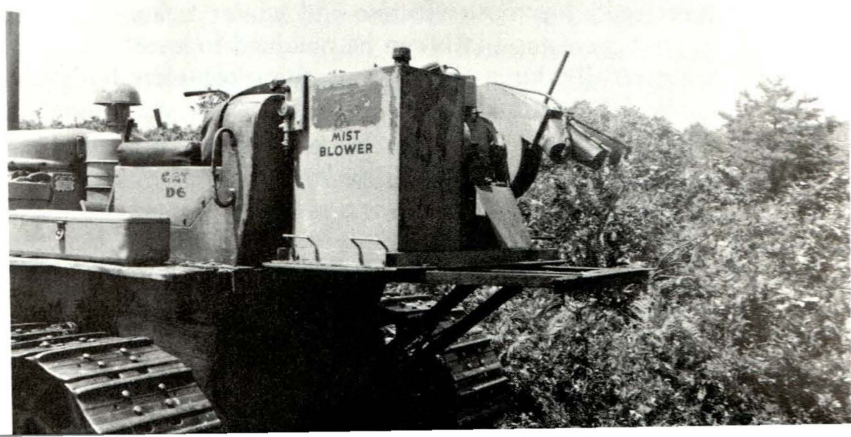
ester dilutions (in oil) on such resistant species as red maple, holly, and dogwood. For example, January treatments with the ester killed 4 to 7 times as many red and sugar maples in northern New Jersey as did comparable concentrations of the amine. Unless stands are composed of susceptible oaks, sweetgums, blackgums, or sweetbays, the ester is preferable to the amine.

- Undiluted amine, in amounts of active material comparable to those applied in dilutions of 80 pounds acid equivalent per 100 gallons, is fairly effective on black oaks (it was not tested on other species). Undiluted ester is usually not as effective as dilutions.
- As a standard treatment for mixed species, 2,4,5-T ester in oil at 80 pounds acid equivalent per 100 gallons is recommended. Make complete, low frills and apply 2 milliliters of solution per cut. Our results to date indicate that 70 percent or more of the treated stems will be completely dead within a year after such treatment, and that crowns will be reduced by about 95 percent.

A number of mist-blower tests have been conducted in the 3-State area during the last 4 years, either with or by the State forestry departments. The tests involved both selective release and conditioning treatments and a range of stand types including high-quality hardwoods, pine-hardwoods, white-cedar—hardwoods, and scrub oak.

The results varied considerably among formulations, species, and the different treatment conditions. For selective release, the isooctyl ester of 2,4,5-T at 1 or 2 pounds per acre in an oil-water carrier was the most effective material in the loblolly pine-hardwood stands

An example of the tractor-mounted mist-blower now used effectively for silvicide spraying of small hardwoods. The timber type seen here is scrub oak in Pennsylvania.



of eastern Maryland, in the pine-oak stands of southern New Jersey, and as an early-season treatment in white-cedar—hardwood swamps. For conditioning treatments, highly effective materials included a butoxy ethanol ester (Trinoxol) in oil carrier at all test locations, the isooctyl ester in oil-water carrier in eastern Maryland and southern New Jersey, and another butoxy ethanol ester (formulated for aerial application) in oil-water carrier in the Pocono scrub-oak areas. In some areas, volumes and rates used in conditioning treatments should be appreciably more than those for selective release. More detailed information on the results of these tests, and precautions to be taken in using mist-blowers, are given in a second paper presented at the 1963 Northeastern Weed Control Conference.³

REVEGETATING MINING SPOILS

Spoil banks and general devastation of the landscape are an unavoidable result of mining—particularly strip mining—for coal. To many people the scene of a stripping is unsightly, even ugly and depressing. Moreover, silt and acid drainage from the spoils may cause serious stream pollution. More than half the counties in Pennsylvania have stripping operations within their borders.

Natural revegetation of mine spoils is a slow and spotty process. Many areas remain practically barren for years; and where plants do come in, the stocking usually is sparse and to weedy species. Accelerated stripping during and immediately after World War II led to the enactment of conservation laws in Pennsylvania in 1945 and 1947 that required some back-filling, grading, and planting (usually trees) on the spoil areas. These laws marked the beginning of serious and sustained public and private efforts in the State to mitigate the objectionable consequences of strip mining.

In 1957, the Station joined several cooperators⁴ in planning and conducting a revegetation research program for the Bituminous Region of Pennsylvania. In 1961, through the interest and financial support of another cooperator⁵ research was extended into the Anthracite Region. The goals were to find the best way to revegetate

³ Little, S. Mistblower treatments in regenerating preferred species in the forests of New Jersey, eastern Maryland, and eastern Pennsylvania. Northeast. Weed Control Conf. Proc. 17: 517-526. 1963.

⁴ Cooperators contributing to one or more studies in the Bituminous Region are: the Pennsylvania Department of Forests and Waters; the Pennsylvania Department of Mines and Mineral Industries; the Pennsylvania Game Commission; the Pennsylvania State University School of Forestry; the Independent Mineral Producers Association; the Central Pennsylvania Open Pit Mining Association; the Izaak Walton League of America; the West Virginia Pulp and Paper Company; and the U.S. Soil Conservation Service.

⁵ The Pennsylvania Power and Light Company.



A typical scene in the Anthracite Region of Pennsylvania—a strip-mined area. Methods of revegetating and screening such areas are being studied in hopes of making the region more attractive to industry.

mine-spoil areas to prevent erosion and stream contamination, hide the scars of mining from the public, provide recreation areas, create food and cover for wildlife, and eventually produce useful timber products.

The Bituminous Program

All studies in the Bituminous Region have been restricted to strip-mine spoils (as opposed to deep-mine waste). In 1958, test plantings established on ungraded strip-mine banks in the late 1940's by The Pennsylvania State University were re-examined to determine how various species had performed after 10 growing seasons. This was followed by a study of 7-year and older plantings established on graded banks in compliance with the 1945 conservation law, and another study of the few mine-bank plantings in the State that were 20 or more years old. These studies showed that, except on the most acid spoils, trees will grow reasonably well and will eventually produce useful products. Japanese larch, Banks pine, Scotch pine, black locust, and hybrid poplar (only one clone tested) were the better-growing species. White pine did very well in some plantings, but its performance was more variable. Gray birch, both natural and planted, is good for cover and bank stabilization, but does not produce commercial products.

Subsequent studies now in progress include a test of 62 hybrid poplar clones on 6 different banks, and a comparison of fall versus



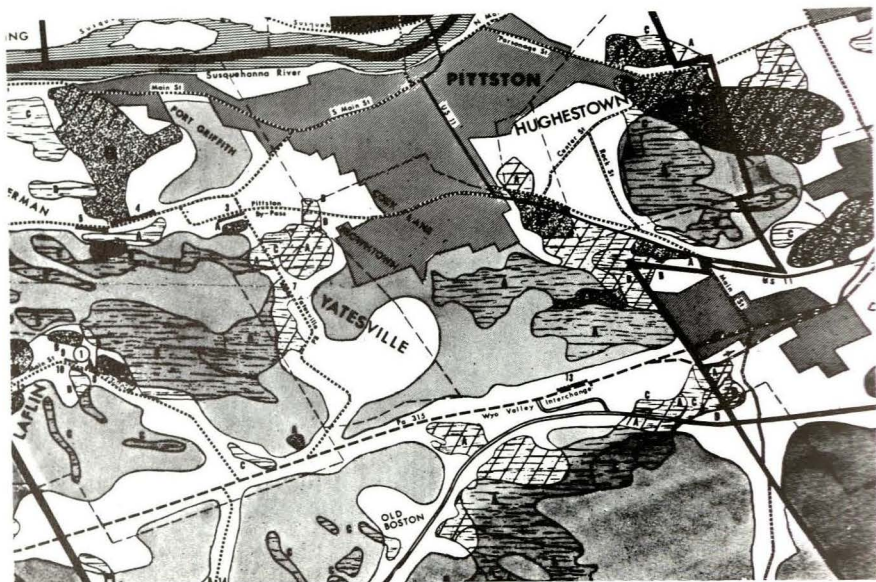
This thin screen of trees—two rows of pines, with an intermingling of volunteer gray birches—hides an ugly strip-mined area from the view of the motorist.

spring planting involving 10 tree and 5 shrub species on 7 different bank types. The hybrid poplar study was inspired by the good performance of the one clone used in the earlier plantings. Second-year results in the current study show a close relationship of survival and growth to bank acidity: the higher the pH, the better the trees grow. Installation of the season-of-planting study, originally designed to extend through 2 years, will be completed in 1963. Preliminary results already indicate that some species survive fall planting considerably better than others.

Plans for the future call for a concerted effort to find species and cultural methods that will provide cover on the highly acid spoils where past plantings generally have failed. Intensive investigation of soil-site relationships will be a part of this study.

The Anthracite Program

Mine-spoil planting in the Anthracite Region is done for the same general purposes as in the Bituminous Region. However, in the Anthracite Region the predominant interest in spoil-bank planting lies in the potential aesthetic benefits; and much of our research there has accordingly been oriented toward aesthetic objectives. Also, because of this concern, both deep-mine waste and strip-mine spoils are included in the program.



A segment of 1 of 41 community maps prepared in a survey of potential planting sites in the Anthracite Region of Pennsylvania. Diagonal lines indicate areas where cover plantings are recommended. Lines of small circles along highways indicate places for screen plantings.

Many people, including community-development planners, believe that prospective new industries will be attracted more strongly to the Anthracite Region if the desolate appearance of some of the landscape can be improved. As a step toward making the Region more attractive, the Pennsylvania Power and Light Company is sponsoring and promoting a community self-improvement campaign to stimulate local tree-planting projects. The plantings would be designed and placed for the primary purpose of masking spoil areas from view along the major highways and from residential sections. Although cover plantings over sizable areas will be required in some places, the purpose often can be served by relatively narrow strips of trees in strategic locations.

A first need in the campaign for community self-improvement was a complete regional survey of the revegetation problem on areas disturbed by mining. This job, now nearing completion, involved the mapping and classification of about 112,000 acres of disturbed land. The disturbed areas have been delineated on 41 separate maps, on which spoils visible from residential sections and main highways

are designated for screen or cover planting. Each map has as a focal point a community of 5,000 or greater population; thus each map serves one community as a chart of its problem and the job to be done.

The survey also included the location of potential water-recreation sites that might be developed as roadside rests or picnic areas.

Concurrent with the survey, research was started to determine the best species for planting anthracite spoils, and to learn something of the site relationships of those species. The first study was an evaluation of existing plantations similar to that done earlier in bituminous plantings. This study is near completion. A new study involving experimental plantings on various types of strip-mine and deep-mine spoils is planned for 1963. Pooled information from the older plantings and from the 1963 study (as it becomes available) will be the basis for planting recommendations for spoil areas in the Anthracite Region.

OTHER RESEARCH

Reproducing Intolerant Species

Regeneration of valuable intolerant species is often a primary goal of even-aged silviculture. Experimental results from studies at several locations provide information on ways to secure and encourage desirable intolerants through natural means.

A study in eastern Maryland provides comparisons of loblolly pine reproduction following several stand-conditioning treatments applied before harvesting. The treatments were: (1) two light winter fires; (2) pulpwood cutting of small overstory pines followed by chemical treatment of all 3-inch (d.b.h.) and larger hardwoods; and (3) a combination of the two above treatments. A control (no conditioning treatment) was included for comparison. Over a 3-year period following a seed-tree cutting, amounts of new pine reproduction varied only slightly between treatments. Most of the advance reproduction either was destroyed during the logging operation or died soon afterward from Pales weevil damage.

The value of the conditioning treatments was in providing a suitable environment for the rapid growth and dominance of the new pine seedlings. Three years after the seed-tree cutting, pine reproduction was free to grow on about twice as many quadrats under the three stand-conditioning treatments as on the control plots. The areas treated with the combination treatment—burning, pulpwood cutting, and the application of chemicals—will probably develop stands of nearly pure pine whereas the control areas appear to be destined for



Success in regenerating loblolly pine in Maryland. Before a seed-tree cutting, stand-conditioning treatments were used here: prescribed burning, and a pulpwood cutting of pines followed by silvicide treatment of hardwoods. A combination of treatments proved best, and new pine seedlings were able to compete successfully with hardwoods and shrubs.

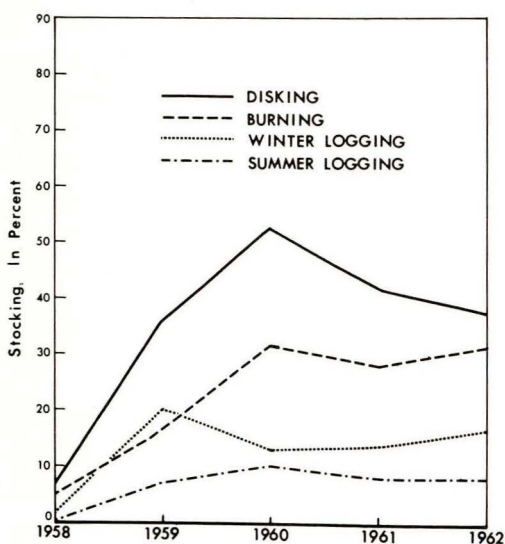
stands of no better than half pine and half hardwood. The two other treatments—burning or pulpwood cutting plus chemical application—appear to be intermediate between these two extremes.

A test of strip clear-cutting and soil scarification was begun in 1954 in a mature stand of paper birch at the Hopkins Memorial Forest, Williamstown, Mass. The initial catch of paper birch seedlings during the year after cutting was twice as much per acre on 2-chain-wide strips as on 1-chain strips. On areas where the soil was scarified (as compared to undisturbed areas), the initial catch was about 5 times as much for the wide strips and $2\frac{1}{2}$ times as much for the narrow strips. By 1962 the numbers of paper birch stems per acre had dropped considerably in comparison with the initial catch; and, furthermore, the numbers had become nearly equal for both strip widths. However, the scarified areas still retained a superiority in numbers over the undisturbed by a ratio of about 2:1 on the wide strips and 3:2 on the narrow strips.

Five-year results are now available from a study at Bangor, Maine, of paper birch regeneration following four methods of site preparation: disking, burning, and winter or summer logging. The percentages of the $\frac{1}{4}$ -milacre quadrats dominated by paper birch were consistently highest over the 5-year period for the disking treatment followed, in order, by the burning, winter logging, and summer logging treatments. The disking and burning treatments favored a high proportion of aspen as well as paper birch, whereas the winter and summer logging treatments resulted in high proportions of softwoods and hardwood sprouts. The site-preparation treatments had no apparent effect upon height growth, and paper birch was smaller than the other species covered in the study.

As part of an even-aged compartment-management study at Elkins, W. Va., a seed-tree cutting was made in 1960 of a 12-acre stand of 80-year-old mixed Appalachian hardwoods; a total of 10 seed trees made up of yellow-poplar, white ash, black cherry, and red oak—all intolerant species—were left per acre. Three growing seasons later, the number of reproduction stems of the above-mentioned intolerant species had risen from almost none before cutting to well over 6,000 per acre; and roughly one-third of these were stump or seedling sprouts. The intolerants made up about one-half of the total number of stems; and they were vigorous and well distributed throughout the cutover area.

Results of four methods of site preparation to encourage regeneration of paper birch. Curves represent percentage of $\frac{1}{4}$ -milacre quadrats stocked predominantly with paper birch, in study at Bangor, Maine.





Results of a seed-tree cutting in West Virginia. Left, the stand immediately after cutting. Right, 3 years later the area had vigorous reproduction estimated at 13,000 stems per acre of desirable species, with a high proportion of yellow-poplar, white ash, black cherry, and red oak.

Cultural Treatments of Immature Stands

After establishment, the growth and development of young plantations and natural stands must be carefully controlled by weeding, thinning, and release treatments. Results obtained from three studies during the year added to our knowledge of the effects—good and bad—of cultural work in immature stands.

The effects of four row-thinning treatments in approximately 20-year-old loblolly pine plantations are being studied in eastern Maryland. The treatments are removal of every second, third, fourth, and fifth row; unthinned check areas are included for comparison. The diameter growth of individual trees over the first 5 years after thinning was positively related to d.b.h., crown class, crown ratio, and severity of thinning. The following equation was developed for the sample trees in the study:

$$\begin{aligned} \text{5-year diameter increment in inches} = & 0.0756 (\text{original d.b.h.}) + \\ & 0.0126 (\text{original crown ratio in percent}) + (\text{treatment-crown class} \\ & \text{value}) \end{aligned}$$

For this equation, the standard error of estimate is 0.22 inches; the coefficient of multiple correlation is 0.86.

The treatment-crown class value corresponds to the elevation term in the regression of diameter increment over d.b.h. and crown ratio for each combination of thinning treatment and crown class. These

values for trees released by the thinning and check trees are as follows:

<i>Treatment</i>	<i>Dominant trees</i>	<i>Co-dominant trees</i>	<i>Intermediate trees</i>
Cut every second row	0.34	0.19	—0.08
Cut every third row	.24	.05	— .29
Cut every fourth row	.07	— .17	— .33
Cut every fifth row	.08	— .16	— .45
Check (no cutting)	— .09	— .22	— .53

In the middle 1920s, a 35-acre planting of white spruce was established on an old burn in New Hampshire by the White Mountain National Forest. Eight years after planting, the hardwood overstory of aspen, maple, birch, and fire cherry was removed from a portion of the planted area, leaving the planted white spruce and some older volunteer firs and black and red spruces. Measurements taken in 1962—nearly 30 years after the overstory treatment—indicated that removal of the hardwoods favored the native softwoods which then competed with and hindered the planted white spruce:

<i>Species</i>	<i>Average d.b.h.</i>		<i>Volume per acre</i>	
	<i>Treated (inches)</i>	<i>Untreated (inches)</i>	<i>Treated (cords)</i>	<i>Untreated (cords)</i>
White spruce	3.9	4.5	5.32	10.64
Native softwoods	7.1	6.4	16.64	8.40
Hardwoods	3.2	4.0	1.93	5.18

Apparently the fairly light shade cast by the hardwood overstory remaining on the untreated area was less detrimental to the growth

A row-thinning treatment of a loblolly pine plantation in eastern Maryland. Diameter growth during the first 5 years after thinning was positively related to d.b.h., crown class, crown ratio, and severity of thinning.



of white spruce than competition from released native softwoods.

A weeding operation in 10-year-old even-aged northern hardwood patches on the Bartlett Experimental Forest in New Hampshire, yielded information on man-hour requirements for crop-tree weeding. One man chose the crop trees and marked competing stems for removal. Two other men cut the marked trees with an ax and Sandvik brush cutter; a few large stems were frilled and poisoned with 2,4,5-T. The number of crop trees chosen per acre on 18 patches varied from 36 to 205. The following equation was developed for predicting weeding times: $Y = 4.06 + 0.088X$; where Y is estimated weeding time in man-hours per acre and X is number of crop trees released per acre.

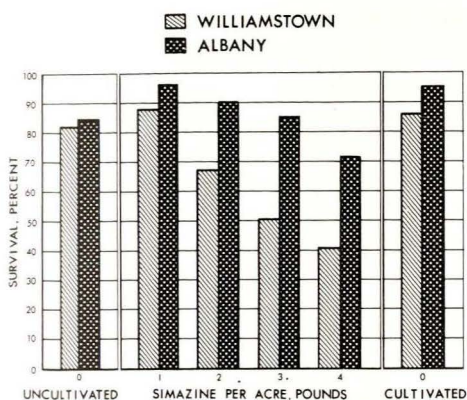
The equation accounts for 58 percent of the total variation in weeding time; the unexplained variation is due largely to differences in terrain and cover among patches. With a standard error of estimate of 3.68 man-hours per acre, the equation provides an approximation—rather than a precise estimate—of man-hour requirements for similar weeding jobs.

Seeding and Planting

The demand for more information on seeding and planting techniques has increased within the last few years because of a growing interest in tree-improvement programs, a desire for cheaper methods of reforestation (possibly by direct seeding), and a greater recognition of the need to supplement natural regeneration in some areas by artificial means.

One of the most troublesome and expensive features of regeneration is in controlling or reducing woody and herbaceous competition. In recent years several chemicals, including Simazine used as a soil sterilant, have shown some promise in this respect. The effects of several rates of Simazine were studied recently on the performance of planted hybrid poplars on heavy clay loam soils at Williamstown, Mass., and on sandy soils near Albany, N.Y. Some plowed and harrowed plots were treated with 1, 2, 4, and 6 pounds of Simazine in water per acre; on other plots no Simazine was used and no cultivation was done during the growing season; and on still other plots no Simazine was used but the plots were cultivated during the growing season to eliminate weed competition.

On both soils (at Williamstown and Albany), survival of poplars was equally good on plots treated with 1 pound of Simazine or with cultivation during the growing season. Survival decreased slightly for the untreated plots and decreased markedly with heavier applications of Simazine. Height growth was by far the best on the



Effectiveness of the weed-control chemical Simazine on two hybrid poplar plantations. Cultivation and a light application of Simazine were equally beneficial to the survival of hybrid poplars, but height growth was better on the cultivated plots.

cultivated plots. Simazine effectively controlled all weeds and grasses of seed origin, but those originating from rhizomes and roots were resistant. Thus, it appears that Simazine may be better suited to weed control where annual weeds are the major problem rather than where perennial weeds are more prevalent.

Applications of hardwood leaf mulch to nursery beds of sugar maple at the Hopkins Memorial Forest resulted in significantly better growth and survival after two growing seasons than applications of pine needle mulch to the beds or no mulch. Growth over 2 years averaged 1.03, 0.91, and 0.42 feet for the three treatments, respectively, and survival was 92, 78, and 58 percent. Applications of coarse, pelleted magnesium ammonium phosphate fertilizer (8-40-0) had no significant effect upon the 2-year height growth of sugar maple seedlings; but survival dropped from 89 to 51 percent as application rates increased from no fertilizer up to 20 ounces per square foot of bed.

Direct seeding trials with jack and red pines in the Pocono Mountains showed that a mineral soil seedbed and protection of the seed from rodents and birds greatly benefit the first-year catch. There was little apparent difference in results between spring and fall sowing; at least 60 and 80 percent of the screened spots, respectively, on mineral soil were stocked with one or more jack or red pine seedlings, whereas stocking of similar unscreened spots was less than 25 percent. For screened spots on humus seedbeds, the stocking ran at least 30 percent less than on the mineral-soil seedbeds.

Tree Improvement and Breeding

As part of a region-wide study of geographic races in southern pines, our New Lisbon personnel and the Maryland Department of

Forests and Parks made an outplanting to compare nine sources of loblolly pine in eastern Maryland in 1953. By 1962 a Maryland source showed the best growth in height and diameter and one of the best survival rates. An Alabama source and an Arkansas source each exhibited somewhat better survival than the Maryland source, but their average heights and diameters were smaller. Sources from Georgia and Louisiana are apparently the least well adapted of any of the nine sources to conditions in the study area:

<i>Source</i>	<i>Survival (percent)</i>	<i>Average d.b.h. of all stems (inches)</i>	<i>Average height of dominants (feet)</i>
Somerset Co., Md.	86	4.7	31.3
Pamlico Co., N.C.	85	4.6	28.9
Cullman Co., Ala.	85	4.6	27.5
Omslow Co., N.C.	80	4.3	27.4
Jefferson Co., Ala.	89	4.4	26.9
Clark Co., Ark.	94	4.6	26.6
Angelina Co., Texas	80	4.3	26.4
Wilcox and Crisp Co., Ga.	66	4.2	25.9
Livingston Parish, La.	64	3.6	23.8

Surveys were made of 20 Vermont sugar bushes by our Burlington personnel primarily to study the variability of sugar content in sap, make individual tree selections for high sugar production, and perfect survey techniques. Out of a 2,000-tree sample, over 30 individuals were tentatively identified as having a sugar content at least 50 percent greater than the average for the sugar bush where they grew. However, because of the possible influence of differences in crown form, growth rate, and tree location upon sugar contents, these trees must be carefully screened before being accepted as potentially high producers for use in future breeding work.

Breeding work with soft maples by our Chestnut Hill project has shown some cases of incompatibility within species and lack of crossability between species. Of 32 attempted cross-pollinations in red maple, using 4 females and 8 males, 7 crosses yielded no seeds and 11 produced less than 1 sound seed per fascicle. Most of these crosses were attempted in each of two successive years. The same four red maple females were crossed with two male silver maples over two successive years. One female gave consistently good seed sets with both males while the other six crosses were almost total failures. When three female silver maples were crossed with five male red maples, all combinations gave small crops of sound hybrid seeds.

Long-term studies indicate that self-pollination in silver maple may result in poor survival. At ages of 9 to 10 years, selfed progenies were only slightly smaller than cross-pollinated offspring of the same

age and exhibited 99 percent survival. At ages of 18 and 19 years, survival of the selfed progenies had dropped to 5 percent, whereas the survival of three cross-pollinated progenies averaged about 50 percent. On the other hand, similar studies extending for more than 20 years indicate that selfed progenies of black, yellow, gray, and paper birches are only slightly less vigorous than cross-pollinated specimens of the same species.

Injury and Mortality

On the Barlett Experimental Forest in New Hampshire a 1-year study of epicormic branching on young northern hardwoods indicated that saplings exposed by patch-cutting formed more epicormic branches than unexposed trees by a ratio of about 3:1. Of the exposed trees, yellow birch produced the most branches, followed by sugar maple and then beech at a ratio of 13:6:1. Twenty-year-old trees produced about 4 times as many epicormic branches as 10-year-old trees. Direction of exposure had no apparent effect upon epicormic branching.

Observations dating from 1954 on the causes of mortality of selected balsam fir trees at Bangor, Maine, showed that balsam woolly aphid attacks in stem and top apparently caused 51 percent of the losses, windthrow and breakage 32 percent, and miscellaneous other causes 17 percent. Results to date indicate that fir trees with the following characteristics should be removed during partial cuttings:

- Balsam woolly aphid stem attack.
- Advanced gout caused by the aphid and reflected by dead tops or abnormally swollen twigs.
- Thin or off-color foliage.
- Lateral twig growth of less than 2 inches, annually.
- Pitch streaks on the trunk.

Ten young white pines that had been injured by grosbeaks during the winter of 1961-62 were carefully observed on the Massabesic Experimental Forest. The birds injured an average of about three-quarters of the buds in the terminal cluster; the terminal itself was consistently destroyed. But nearly a full complement of new lateral buds developed in spring 1962. Two or more leaders developed on most trees and, in some cases, existing lateral branches began to turn upward. Height growth did not seem to be greatly inhibited by grosbeak damage.

WATERSHED MANAGEMENT

IF, in our Annual Reports, watershed-management research results tend at times to confuse the reader, that's because it's a confusing field. For instance, we are at one and the same time:

- Calibrating or treating 28 experimental watersheds that range in area from 22 to 1,530 acres and determining the effects of the treatment.
- Conducting small plot studies on and off these watersheds to learn about the hydrologic processes that, on the watersheds, govern the results of treatment.
- Making regional studies of climate and streamflow for a better understanding of their magnitude and variability.
- Measuring such diversities as sediment, snow, and solar radiation.
- And in general, while pursuing the specific, we are seeking—perhaps intuitively—conceptual patterns that tie these endeavors together.

Behind these several approaches we continue to have the singular objective of attaining ability to predict with confidence and accuracy the effects of forest conditions and management practices on water yield and quality.

Cost of Increasing Water Supplies

In last year's annual report we noted the sizable increase in annual flow that had come from the clearcut watershed at the Fernow Experimental Forest. The question arose: How much would it cost to continue that increase? We made some estimates: through cutting, and aerial spraying every 5 years to kill small trees and low vegetation, the average annual increase in water yield could amount to 5.3 acre-inches or 144,000 gallons per acre: The spraying would cost \$9 per acre every 5 years or \$1.80 per year; timber income forgone would amount to \$4 per acre per year. Total annual per acre costs of \$5.80 in terms of water yield would amount to 4 cents per 1,000 gallons. In a forthcoming paper (Journal of Forestry) that gives these results in more detail we point out the considerations and care that are required in such an undertaking.

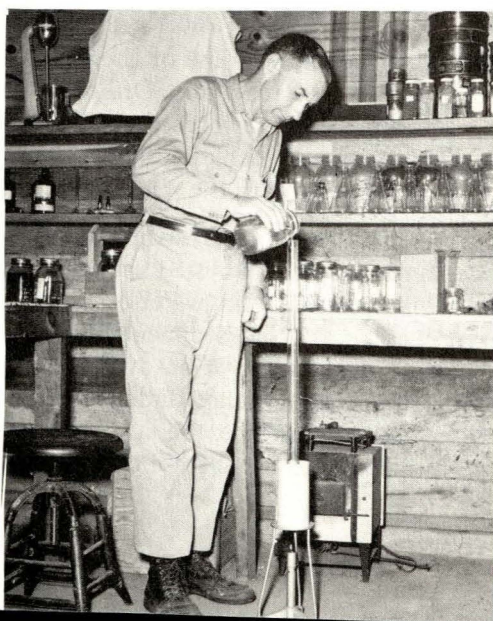
Logging and Water Quality

Log a steep slope of the Alleghenies or the White Mountains and you will get erosion, and mud in the streamflow. Is that a fact? No—it isn't.

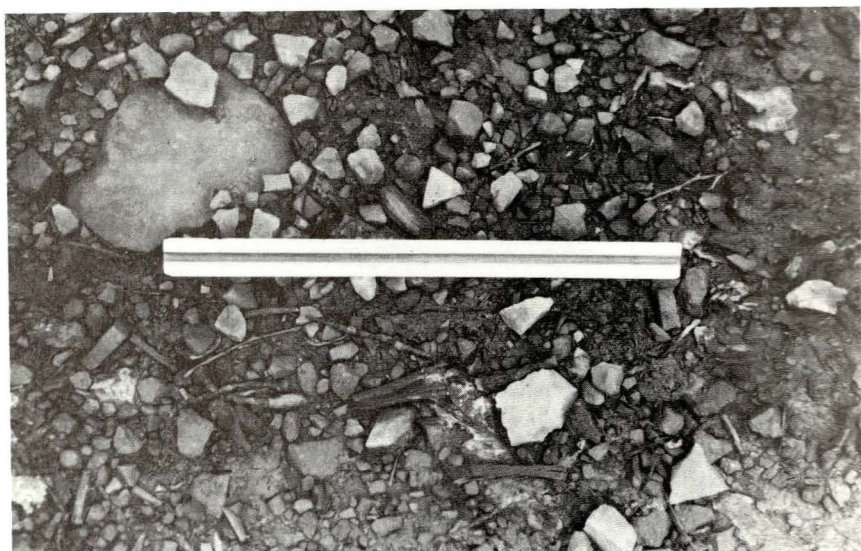
Another year's study of data from the Fernow Experimental Forest, plus some checking around elsewhere, has provided some new insights on this question. We have found that the influence of logging on water quality depends on a number of factors. For instance:

- Location of the logging road. If the logging road is run close to the stream, as was done at the Fernow on the commercial clearcut watershed, muddy water from the road can easily reach the stream channel. If the roads are kept away from the channel, as in the intensive selection watershed, the runoff will filter through the forest floor before it reaches the stream. The proof: of 203 water-quality samples taken from each of the watersheds during a 3-year period after logging, 77 from the commercial clearcut had turbidities in excess of the drinking-water standard of 11 parts per million, 37 had turbidities greater than 100 ppm, with 13 greater than 1,000 ppm (dirty brown). Where roads were kept away from the streams, all but 2 of the 203 samples were within drinking-water standards.
- Time. During logging the average turbidity from the commercial clearcut was 490 ppm. The first year after logging it dropped to 38 ppm, and the second year to 1 ppm. Obviously, the time to prevent sedimentation from poorly located roads is during the logging operation.

Determining water quality at the Fernow Forest with a Jackson turbidimeter. Studies here have shown that, when logging roads are kept away from streams, water quality is affected very little.



- Soil. Time in this case was abetted by the stony soil because washing away of the soil particles from the road surface left the stones as a cover—a natural gravelling—that protected the underlying soil.



A typical erosion pavement on a skidroad in the Fernow Experimental Forest. Exposed by washing away of soil particles, the surface layer of stones protects the underlying soil from erosion.

- Subsurface flow. Some of the erosion was caused by water intercepted by the road cuts. Ordinarily this water flows through the soil downslope towards the stream; intercepted by a road cut, it flows down the bank and down the road, picking up soil particles as it moves toward the stream.

The rapid reduction in sediment load points up the general situation in northeastern forested watersheds where, despite heavy cutting in the past, high-quality water is still produced. As a general observation, we can say that sediment that gets into the stream washes in from the roads; little or no overland flow occurs elsewhere as long as the forest floor is not unduly disturbed. At the Fernow clearcut watershed, for instance, the largest summer-storm increase in stream-flow amounted to 0.46 area-inch of which, a study of the hydrograph

showed, only 0.01 inch was overland flow from the skidroads; the greater part was subsurface flow.

This then suggests that regardless of the amount of timber cut, much of the hydrologic benefits of the forest are present as long as the forest floor remains intact. This was the situation at the Fernow: despite the heavy cutting, the forest floor was little damaged, infiltration rates remained high, and increases in summer stormflow were due to a reduction in evapotranspiration (and thus a reduction of soil-water-storage opportunity) rather than an increase in overland flow.

Watershed Storage

How much water does a watershed hold? The answer to this question would help us understand the hydrology of an experimental watershed, for knowing its storage capacity we could relate it to incoming precipitation and outgoing streamflow. We know from experience that watershed storage cannot be measured by intensive soil-moisture sampling: our forest soils are simply too variable and, most of all, too stony to permit this. So, a simple budgeting procedure was tried in which heavy summer storm rainfall after a prolonged drying period was related to the consequent runoff; the difference, with a correction for evapotranspiration during the rainfall period, is a measure of watershed storage for that particular situation. For two of the Fernow watersheds, maximum storage was calculated to be 4.3 and 4.7 inches; for the Dilldown watershed in Pennsylvania, 5.4 inches; and for one of the Hubbard Brook watersheds in New Hampshire, 3.6 inches. These values appear to be less than maximum values estimated roughly from soil-moisture storage capacities, which suggests that the soils were by no means completely dry at the end of the selected drying periods.

Humus, Leaves, Snow, Frost

A humpy ground surface is found in many forest stands in the Northeast where long ago windthrow has left the forest floor pockmarked with mounds and depressions. This sort of microtopography was studied at the Bartlett Experimental Forest in relation to leaf accumulation, humus formation, and soil frost. Here, under northern hardwoods, about 5,500 pounds of leaves per acre accumulated in the depressions, 2,600 pounds on the side slopes, and 1,500 pounds on the mounds. The formation of mor humus was found to have a similar pattern: 5.9 inches in the depressions, 3.0 on the slopes, and 1.5 on the mounds. No concrete frost was observed in the depressions; and frost was three times more frequent on the mounds, where

it averaged 2.7 inches deep, than on the slopes, where it averaged 1.6 inches.

The insulating effect of snow was observed during three winters of a frost study at Hubbard Brook. Concrete frost was found at only 4 percent of the sampling points. Most frequent frost occurrence at any one sampling came after a cold period without snow cover, when 23 percent of the sampling points had frost. The snow-insulating effect on frost became evident from thermocouple readings taken in the air, snow, and soil. If freezing of the soil occurs at 25°F., these measurements indicated that no freezing will occur under 18 inches of snow with air temperatures as low as 4°F., a 12-inch snow depth prevented soil freezing down to 5°F., and a 6-inch depth to 25°F. These results support the general observations that snow depths over 18 inches will prevent frost penetration.

Other Watershed Studies

One intensive analysis of watershed data was completed during the year and one was started. The one completed resulted in development of a streamflow-prediction system for calibrating the Dilldown Experimental Watershed in Pennsylvania. This system, based on 6 years of daily climatic and streamflow measurements, provides a means for predicting annual and monthly streamflow from precipitation and air-temperature measurements. This prediction system will be used to help determine the effects on water yield of converting the Dilldown cover from scrub oak to high forest.

At our cooperative project with the State University College of Forestry, at Syracuse, N.Y., analysis was started of the 50-year streamflow record of the Sacandaga river in the Adirondacks to determine if during this period there has been a change in water yield and, if so, if it can be related to the long-time protection given to this 500-square-mile forested watershed.

Installations and Measurements

Our Hubbard Brook office was completed this year, a multi-purpose building that provides office and laboratory space, quarters, and a magnificent view of the White Mountains. Also, the road into the Experimental Forest was pushed forward another 2 miles, giving access to three more weir sites.

As for instrumentation, we acquired at Hubbard Brook a nuclear soil-moisture meter, the only instrument with which the moisture content of the stony soils can be measured. We also procured a steel tower to hang instruments on; 72 feet high, it provides access to



The new laboratory/office building at Hubbard Brook, completed in 1962, provides facilities for watershed research and quarters for field assistants.



A nuclear soil-moisture meter in use at Hubbard Brook. This is the only effective device we know of for measuring moisture content of stony soils.

above-canopy and canopy elevations for climatic measurements.

The problems of measuring precipitation on experimental watersheds that have been clearcut became evident in the Fernow records. They showed that the catch of annual precipitation was reduced by 3 percent and the winter catch by 7 percent because the rain gages were exposed to greater wind movement. Shielded gages should be used in such situations.

A 3-day conference of the watershed staff and other invited experts was held on collection and compilation of streamflow records. Its purpose was to compare present procedures on the handicraft level, and their costs, with recently developed machine procedures. We concluded that a small operating savings could be made by using the machine procedures at the cost of a large investment in equipment. There are possibilities, not particularly self-evident, that the machines can do a better job of analysis.

And Records

Another year of climatic and streamflow records were obtained at the Fernow Forest and Hubbard Brook. And similar records were obtained through the continued cooperation of Louis Ningard at the Baltimore, Md., watersheds; John Heilman at Newark, N. J.; and Prof. William Sopper at Pennsylvania State University.

The climatic tower at the Hubbard Brook Experimental Forest in New Hampshire. Used to support meteorological instruments, this 72-foot tower provides access to various levels within and above the tree canopy, for climatic measurements.



FOREST INSECTS

MUCH of the damage wrought by insects in the forest is striking. Even the uninterested traveler cannot miss seeing the graying, beetle-killed pines by the roadside or lake edge. And the hillside suddenly turned brown by the ravages of a defoliator contrasts sharply with the lush green backdrop of surrounding hardwood-covered hills not yet invaded. Aesthetically or economically, the loss is apparent.

The man in the woods, the practicing forester, is aware of damaging effects that are less noticeable. Current shoot and terminal injury to younger trees and the crooked, forked, and stunted relics among the older trees are graphic indicators to him of a cause-effect relation that means losses in time and money. The destruction of a seed crop—in a particular area where seedbed preparations and other costly operations have been completed perhaps—means a delay in restocking and leaves the forester with the serious problem of planning the next regeneration attempt. Also, he knows that the pines killed by bark beetles must be replaced—at some cost—or less desirable shrubs and trees may occupy the space. And the severely defoliated hardwoods on the hillside will put on less current growth, become susceptible to secondary insects and diseases, maybe suffer dieback of twigs and branches.

There are other effects less discernible, or indirect, but nonetheless real. Heavy defoliation of a forest stand allows increased insolation, with consequent greater drying of the litter and surface soil. This can result in rootlet mortality (and tree mortality due to "unknown factors"), higher fire hazard, and other deleterious changes. And the presence in large numbers of the culprit—an obnoxious hairy caterpillar, say—will clear the stand of all but the least squeamish picnickers and most hardy seekers of nature in the raw.

There are, too, the interactions with other destructive agents that can be assessed only on a long-term basis. The preponderance of misshapen and unmerchantable white pines and the generally low quality of hardwoods in the Northeast attest to the near-catastrophic cumulative effects of insect attack, disease, and other injurious agents, and the selective high-grading operations of man himself.

The hard fact is that we do not yet know what is the full impact of insects and other destructive agents on either productivity or value

of the forest resource. The most intensive surveys and appraisals to date have failed to give us complete answers. We must have better means of recognizing and measuring current losses and predicting future impacts. Net forest-growth projection will remain uncertain and inaccurate as long as insect impact is not properly accounted for.

Insect Impact

Our Division of Forest Insect Research has begun a study of the impact of insects on northeastern forests. This is a large undertaking that will require careful planning to begin, plus a large body of data and experience. New analytical techniques will be needed to sort and process the data. First, however, we must review the present concepts of growth impact by insects and other destructive agents; we must distinguish the various means by which the direct and indirect, short- and long-term effects are felt; and we must derive suitable expressions or models encompassing the many components. This review and evaluation are under way.

One possible model for analyzing, in a gross way, the impact of insects on forest stands has already been considered. Because the time element—that is, *when* the damage occurs in the life span of the forest crop—is so important, this model equates productivity (or value) at harvest with surviving numbers or volume (or dollar value) of trees in successive age intervals. In its simplest form, this model is expressed as follows:

$$Y \text{ (or } V) = N \cdot S_1 \cdot S_2 \cdot \dots \cdot S_n$$

where, in terms of productivity,

Y = net productivity (merchantable trees/acre).

N = number of seedlings/acre established in the first year.

S_1, S_2, S_n = proportion of merchantable or crop trees per acre remaining at end of periods 1, 2, . . . n . These periods may be 1-year, 5-year, or n -year intervals; or they may be the seedling, sapling, pole-timber, and saw-timber stages as defined for the tree species involved.

The equation is made additive, and thus simpler to analyze, by converting all values to logarithms. The form of relationship between the dependent and the "independent" variables, and the degree of correlation between the latter, are easily determined statistically. With this model we can first analyze the degree to which variations in survival (or loss) of merchantable trees in the successive age intervals influences the final yield. If we know or can find out what insects were noticeably present in these age intervals, and the manner and degree of damage caused by them, we can develop submodels to analyze their effects jointly and separately.

Of course, the simple trees-per-acre measure of productivity is applicable only to pure, even-aged stands such as plantations. Volume or basal-area figures are needed for mixed, uneven-aged stands. These require a more complex model, but the age-interval breakdown will be similarly helpful. Logically, the analytical use of models such as the above will provide a framework within which *all* components of productivity or value of managed forest units can be evaluated.

The analytical approach has already paid off in one problem. Conventional appraisals of damage by the white-pine weevil have been based on estimates of the percentage of trees weeviled in the current (or previous) year. For control decisions, the allowable limits of weevil damage have been expressed in these terms. But the individual tree leader is the attack site of the weevil; and as the number of leaders per acre increases with repeated weevilings, the arithmetic calculation of percentage weeviling based on the number of trees per acre becomes increasingly difficult to interpret. Direct comparison of stands with different histories of past weeviling is liable to error.

A new damage index—the number of trees remaining free of weevil (or weevil-like) injury—has been developed for decisions on weevil control. This index expresses allowable damage in terms that can be directly interpreted and used by the forest or plantation manager. The field sampling data are obtained just as easily, and no transformation of percentages is required for estimation of the sampling error. Biologically, the number of unweeviled trees in successive years is a more stable variable than percentage of trees weeviled. When plotted on a graph, it describes a smooth curve; whereas current percentage of weeviling generally appears as a broken line with the direction and amount of change somewhat unpredictable. This new index is being incorporated into a new set of guidelines for the weevil-control program in New York, and it is equally applicable elsewhere.

The study of insect impact is but one of our four major lines of investigation in forest-insect research. The others are (1) insect biology—fundamental studies of insect physiology, genetics, behavior, and population dynamics; (2) biotic control—the development of biotic means of controlling destructive pests, including the use of microbial agents, insect parasites and predators, and genetic manipulation; (3) chemical control—the development of methods of control by chemicals, which includes the use of toxicants, chemosterilants, and antimetabolites. Some highlights of research in these projects follow.

Insect Biology

This is the core project of our insect-research program. It necessarily covers a wide range of insects and subject matter. It provides the basic information needed to evaluate the role of specific pests in the forest ecosystem and to develop means of controlling them efficiently.

The work on certain major pests is directed primarily at the question of *why* they operate as they do; for others we are simply trying to find out *what* they are doing. For example, current studies of the white-pine weevil include new research on its neurosecretory system (a basic element in behavior) and differentiation of the closely related species of *Pissodes* by serological and chromatographic techniques. Research on the gypsy moth includes the final stages of a study of the effects of gamma irradiation on reproduction, development, and survival; a series of studies on the complex of biotic agents affecting abundance; and a study of larval aggregative behavior and its population consequences. Life-history studies of the white-pine cone beetle and the pine leaf aphid were recently completed, and investigation is under way of key features of their ecology.

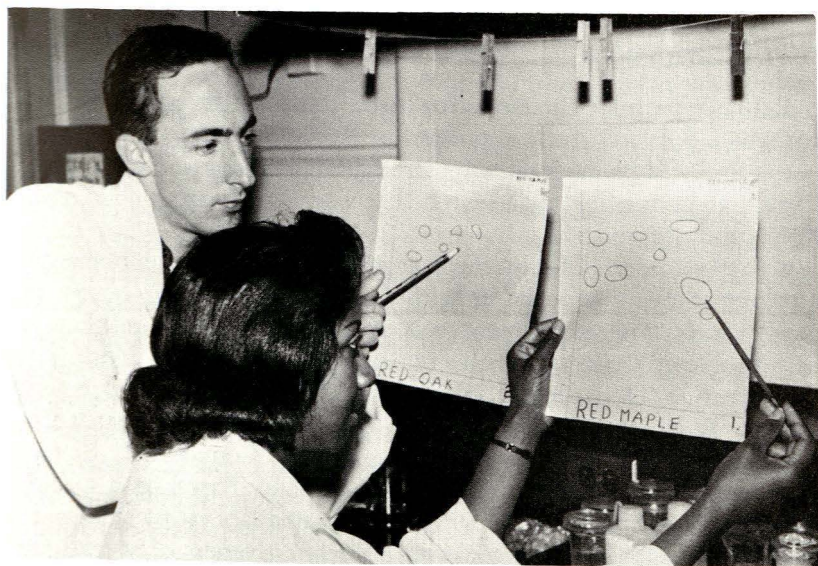
The pine leaf aphid has proved particularly interesting. Study of its full life cycle over a 2-year period showed that dispersal between alternate hosts—white pine and red (or black) spruce—is a highly significant factor in the development of infestations and the pattern of damage caused. Now, for more detailed study the point source of the migrating forms must be determined and a means developed for labelling large numbers for recapture. A radioactive tracer seemed the logical solution. Since the insect is contained within its spruce host while in the gall, and large numbers of the winged form can develop in the galls on a single tree, tests were made with small trees in the greenhouse to determine if the insect could be tagged by introduction of a radioactive element into the tree.

Actually, eastern spruce gall aphids and Norway spruce were used because the proper stage of the pine leaf aphid was not available. The two insects are very similar in form and habit. The winged stages are approximately equal in size and structure and hence in their labelling and aerodynamic properties. The vascular systems of red and Norway spruce are similar. Phosphorus³² was selected as the radioisotope since it has been used with many insects, including aphids, without injurious effects. Moreover, it is translocated rapidly in trees and is incorporated readily into the insect body. Carried out with proper safety precautions, the experiments in 1962 showed that spruce gall aphid winged adults can be tagged effectively with P³² by introducing the radioisotope into the host tree. The degree of

radioactivity recorded for individual insects varied with the amount of material administered and the size of the insect. Special cylindrical sticky traps also proved helpful in censusing field populations of pine leaf aphid in the flight period. These techniques will be used in the field in 1963 to learn more of the dispersal pattern of this insect.

The immunity of red maple to attack by forest tent caterpillar, gypsy moth, and certain other omnivorous defoliators is an interesting phenomenon with important implications. It is rather startling to see the flush of green foliage in a stand of mixed hardwoods that is otherwise stripped clean. Where red maple forms a dense understory to susceptible species such as the oaks, a definite 2-storied appearance results from heavy attack by the defoliators. The growth of the red maple is strongly stimulated by this "release treatment" and the succession of tree species in the stand itself may be altered by continued and frequent attack. What is it about red maple that gives it this immunity?

To find out, we are studying the primary chemical constituents of red maple leaves by paper partition chromatography. And for comparison, we are making similar separation of the foliage of a suscep-



Laboratory workers analyze chromatographs in their search for a clue to a riddle: is there some chemical component in the leaves of red maples that makes them immune to attack by the forest tent caterpillar, gypsy moth, and other leaf-eating insects?

tible tree species, red oak. Four methods of extraction, seven solvent mixtures, and seven location reagents (including ultraviolet light) are being tried. Excellent results—with clearcut distinction of the leaf components of the two species—have so far been obtained with several combinations. The best separation is shown on a chromatogram, where the components are first partitioned off in one direction by a particular solvent, and then further differentiated by movement in a direction perpendicular to the first by means of a second solvent.

The next step is to remove the specific components from the filter paper of the chromatogram and introduce each separately into the food of the insect. To avoid confounding with physical stimuli (or inhibitors) characteristic of the foliage of each tree species, an artificial medium has been developed on which very young gypsy moth larvae feed successfully. The separate components of the leaves will be added in turn to this medium, and the reactions of the larvae will be observed closely. A material may be obtained in this way that will have practical usefulness in protecting susceptible trees from feeding damage by the gypsy moth and the other defoliators. If economical, large-scale applications of such a material could effect real control through starvation. And, regardless, we will obtain a better understanding of the bases of host selection by these and other leaf-feeding pests.

Biotic Control

Reliance on toxic chemicals for insect control—the present concern for which is so colorfully expressed by Rachel Carson in *Silent Spring*—can and will be moderated by alternative methods of biotic control. This is an active field of research that warrants greater public recognition and support.

A major undertaking by the Station in 1962 was a comprehensive airplane spraying experiment with *Bacillus thuringiensis* against the gypsy moth. The experiment was conducted in May and June in eastern New York with full cooperation by the New York State Conservation Department; New York State Museum and Science Service; Plant Pest Control Division, U.S. Agricultural Research Service; Bacteriology Department, University of Connecticut; Bioferm Corporation; and Stauffer Chemical Company. Based on a preliminary spraying experiment in 1961 and detailed laboratory studies, the experiment was designed to measure the effectiveness of several concentrations of *Bt* in both oil and water formulations. High concentrations of virus polyhedra (the specific wilt-causing pathogen of the gypsy moth) were added to one-half of the *Bt* mixtures. The highest dosage of *Bt* applied was 4 pounds in 4 gallons of liquid per acre;



These screened cages contain gypsy moth larvae feeding on foliage that was exposed to aerial spraying of *Bacillus thuringiensis*, a biotic agent that has been found effective for control of the gypsy moth (and the linden looper and cankerworms).

the lightest dosage was 1 pound *Bt* plus 50 billion polyhedra in 2 gallons per acre. A commercial anti-evaporant and sticker was added to the water sprays.

A total of 24 plots, ranging in size from 25 to 150 acres, were treated in 3 time series, with an untreated check plot in each. The first series occurred when the larvae were in the first and second instars; the second and third series when the larvae were in the second and third instars. Two Stearman planes—one each for the oil and water formulations—distributed the spray.

The overall control effect on each treated plot was estimated from egg-mass counts before and after spraying. Two criteria of comparison were used: (1) the percentage reduction in egg masses, and (2) the estimated *number* of egg masses per acre after treatment. Because each gypsy moth adult female generally lays only one egg mass, this count is a good measure of surviving females. Other methods were also used to evaluate the effects of the *Bt* sprays: mortality of larvae placed on treated foliage (from the plots) in screen cages, periodic counts of living larvae, frass sampling, and defoliation estimates. Deposit of the *Bt* was assessed by counts of spores obtained from leaf samples and by culture of the bacterium in petri dishes that had been exposed to the spray.



These petri dishes, now growing cultures of *Bacillus thuringiensis*, were exposed to test the effectiveness of aerial spraying of *Bt*. The cultures indicate effective spraying.

One treatment—the 4 pounds *Bt* in 4 gallons of water per acre—gave an acceptable degree of control (95 percent reduction in egg masses, residual 26 egg masses per acre). However, nearly all plots showed much reduced defoliation. Feeding by the insect ceased very quickly in some plots. Rapid kill of linden looper and cankerworm larvae—then abundant in the plot areas—was noted. Improvement is needed in certain technical characteristics of the commercial preparation of *Bacillus thuringiensis*, but there is little doubt that we now have an effective addition to our arsenal of defense against the gypsy moth (and linden looper and cankerworms).

Another exciting development was the acquisition from Dr. F. T. Bird in Canada of a virulent strain of the polyhedral virus specific to the red-headed pine sawfly. A small amount was retained at our New Haven Laboratory; small quantities were sent to Forest Service entomologists in the Southeast and deep South for faster propagation

in natural sawfly infestations. Larger quantities of the virus have been obtained for larger scale propagation and possible use in 1963.

Practical use was made of the polyhedral virus of the European pine sawfly on a larger scale in 1962. A number of red pine plantings in New Jersey and several other states were treated to control this widespread pest.

Such means of biotic control should be utilized whenever biologically feasible.

Chemical Control

Chemicals can be used safely and effectively in a number of ways to control insect populations and minimize damage to trees. Insecticidal sprays, properly applied, have the advantage of quick action and high kill against a particular pest. Other chemicals can provide as good protection to the tree crop without the toxic action.

Screening tests of candidate repellent-deterrent chemicals have been conducted at the New Haven Laboratory for 3 years to find a material that will minimize twig feeding by the smaller European elm bark beetle and thus reduce the incidence of Dutch elm disease. Twelve chemicals (of over 200 tested) have shown promise. Four of these were tested under field conditions in 1962. Replicated lots of small American elms were treated with the test materials, a specified number of beetles were placed on them, and plastic screen cages were fastened over the portion of the tree containing the beetles. The insects were left undisturbed for 72 hours. The cages were then removed and the number of feeding scars, living beetles, and dead beetles were counted and recorded. None of the materials completely prevented twig feeding, and relatively high beetle mortality occurred in all cases. Of those tested, ENT 262 (phthalic acid, dimethyl ester) gave the best protection; but the confounding with mortality does not allow prediction of its repellent-deterrent effects.

Preliminary tests with these chemicals are being conducted with the white-pine cone beetle. This insect has proved extremely difficult to control with conventional sprays, and an effective repellent material might well provide protection to a cone crop over the attack period in the spring.

Other chemical control experiments were conducted with Phosphamidon (a systemic insecticide), and lindane and Zectran (a carbamate) with the extender Aroclor for control of the white-pine weevil. We are continuing to seek more efficient means of controlling the weevil by insecticidal sprays, and to develop safe and efficient methods of applying such sprays for the different field conditions generally met.

FOREST DISEASES

ONE of the deterrents to present and future productivity of forest land in the Northeast is the damage to timber stands that diseases cause. To determine how best to avoid and reduce this damage, our current research program includes studies of organisms that produce diseases and studies of tree responses to pathological and physiological conditions.

The complexity of many diseases is constantly being recognized. Some of the simple explanations presented in the past need to be reexamined in light of current knowledge. Information from other disciplines is frequently needed before a disease problem can be adequately understood. For example, an understanding of the cause of oak decline and the role played by root fungi became possible only after sufficient knowledge was obtained of predisposing factors involving defoliating insects, adverse weather, and unfavorable soil conditions.

In a recent analysis of forest-disease problems in the Northeast, highest priority was assigned to research on the decays and stains in standing timber, root diseases in coniferous plantations, and die-backs and wilts of several major tree species. Our current disease-research program gives emphasis to these problems of high priority.

Decays and Discolorations

Decays and discolorations in standing timber in the Northeast are responsible for greater loss in usable timber volume and values than any other class of disease. Our research has involved two approaches: (1) introducing decay-producing fungi into sound trees and studying the behavior of the pathogen and the host response; and (2) cutting and dissecting infected trees and through laboratory studies attempting to reconstruct the pathological events of the past. The following is a brief summary of the status of these studies.

Inoculations of the principal rot fungi into major tree species have been completed on schedule. Preliminary dissections were made of hardwoods inoculated 4 years ago. This was in preparation for the regularly scheduled 5-year dissection study and was done to perfect sampling techniques and data recording.



Sections of a red maple sprout clump dissected in studies of decay and discoloration. Old branch stubs were found to be the main entry point for decay-causing fungi.



Closeup of a dissected red maple stem, showing decay and discoloration due to infection of a logging wound. Some 290 trees have been dissected in our studies of logging injuries to northern hardwoods.

In continuing the study of decay and discoloration following logging injury to northern hardwoods, 102 more wounded trees were dissected and studied in 1962. This makes a total of 290 trees dissected since the study began. The wounds ranged in age from 8 to 60 years. The following information was obtained:

- The appearance of the wound surface is usually a better indicator of internal decay and discoloration than the size of the wound.
- Fruiting bodies of decay fungi were more common on old wounds than were the fruiting bodies of the non-hymenomycetes that cause discolorations.
- Species of *Hypoxylon* were not as common on older wounds as they were on wounds less than 20 years old.
- Frost cracks appeared to start from old logging wounds on some trees, especially on paper birch.
- The fungi that invade the wood through wounds seldom invade the wood formed after the tree is wounded. If a northern hardwood tree was 6 inches d.b.h. when wounded, the decay and discoloration is usually limited to a column of that same diameter.
- Bacteria, as well as fungi associated with discolorations, were usually isolated from the wood surrounding rot columns.
- Laboratory studies indicated that discoloration in wood can be caused by *Hypoxylon* spp., *Phialophora* spp., and *Trichocladium* sp.

An experiment was begun in 1962 to test the effectiveness of several materials in reducing or eliminating the development of stains, decays, or cankers in wounds on living trees. Artificial wounds were made with increment borers in yellow birch on the Hubbard Brook Watershed and in red maple on the Bartlett Experimental Forest. The wounds were then treated with the following materials to test preventatives to pathogenic infections: *Acti-dione*, an antibiotic that has successfully inhibited some disease fungi; *Arasan*, a broad spectrum fungicide that possesses chelating properties; 8-*Hydroxyquinoline*, a chelator sometimes also used as a fungistat; *Nacap*, a corrosion inhibitor and metal deactivator having fungicidal properties; *Paraformaldehyde*, a biocidal material in tablet form recently developed for use in sugar maple tap holes; and *Elmers Glue-all*, a resinous material.

Fourteen more red maple sprout clumps on the White Mountain National Forest were dissected and studied, bringing the total to 72. Old branch stubs were found to be more important than the parent stumps as infection courts for decay fungi. *Polyporus glomeratus* was the major decay fungus found to be infecting the stems through branch stubs.

Fomes Annosus Root Rot

Fomes annosus root rot is now the leading plantation disease in the Northeast. Each year, as the number of recently thinned coniferous plantations increases, the number of severely infected plantations mounts. In some areas, the disease is so severe that thinning of red pine plantations has been discouraged, and even planting of red pine is being viewed with some skepticism. Heavy damage in thinned white pine plantations has occurred in central Pennsylvania.

Our research on *Fomes annosus* root rot in coniferous plantations emphasizes factors that influence disease behavior, the effectiveness of control measures, and the development of a technique for more rapid evaluation of chemicals used for control. Results of the past years' research follow:

- Less root rot occurred in those plots where trees were of highest vigor.
- Plots with greatest root rot damage had the poorest internal soil drainage.
- No appreciable differences in soil pH were found between plots with little root-rot damage and plots with great root-rot damage.

Soil fumigation was tried here in our search for a way to stop the spread of *Fomes annosus*, now the leading disease of conifer plantations in the Northeast. The pit was dug to get a measure of root infection in this treated plantation.



- The organic content of the A horizon was less in the plots with great damage than in plots with little damage, averaging 4.7 percent and 7.4 percent respectively.
- The fungus flora developing on stumps treated with urea was strikingly different than that on creosote-treated stumps or on untreated stumps. No evaluation has yet been made of the effectiveness of applying urea on freshly cut stumps to prevent *Fomes annosus* infection.

Our 1961 Annual Report referred to the observation that thinning coniferous plantations by poisoning trees rather than by cutting seemed to avoid creating infection courts for *Fomes annosus*. An experiment was begun on the Pocomoke Forest in southern Maryland to test the validity of this observation.

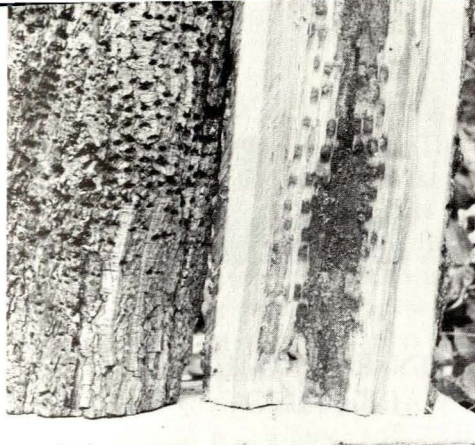
Ash Dieback

A dieback condition has caused mortality of white ash for a number of years. The seriousness of ash dieback was not fully recognized until a state-wide survey conducted by the New York State Conservation Department in 1960-61 revealed that more than a third of the white ash trees of all age classes in New York were dead or diseased. Ash dieback is known to be damaging in parts of Pennsylvania and in western Connecticut.

The cause of the disease is not known. Two fungi, *Cytophoma pruinosa* and *Fusicoccum* sp., were found to be common on cankers and on dead twigs of affected trees. To test the pathogenicity of these fungi, a series of inoculations was made. On apparently healthy white ash trees in New York and Connecticut inoculations made in May and June had not caused cankers by late August. Following inoculations made on green ash trees in Massachusetts and in Pennsylvania, only one canker formed: this was on a stunted and chlorotic tree in Massachusetts. Additional inoculations will be made during the mid-winter season. Another experiment is in progress to determine the possible relationship of bark moisture to the development of *Cytophoma* or *Fusicoccum* cankers on white ash.

Chestnut Blight

Cooperating agencies and individuals continue to report the survival of large American chestnut trees within the area devastated by the blight. A total of 239 of these American chestnuts have been included in tests for blight resistance since 1954. The progeny from more than 90 percent of these trees have succumbed to the blight during the tests. The survivors are undergoing additional testing.



Some ring shake in hemlock seems to be associated with injuries caused by a bird, the yellow-bellied sapsucker. The tree section on the right reveals sapsucker wounds in the annual ring that separated to cause the shake damage.

The Agricultural Research Service at Beltsville, Maryland, treated 59 chestnut seedlings with colchicine to induce possible multiplying of chromosomes in cells. The treated trees have been outplanted in Chester County, Pennsylvania. Induced tetraploidy will be studied for possible effect on tree growth or disease resistance.

Sapsucker Injury and Ring Shake

Some of the trees cut and dissected during decay studies were found to have been severely fed upon by sapsuckers in previous years. The culprit is believed to be one of our common northern birds, the yellow-bellied sapsucker, which pecks holes through the bark to feed upon cambium and sap. Particularly in hemlock, the old sapsucker wounds were found to be in the growth ring that separated to produce ring shake. Observations were then made on 25 hemlocks that had been injured in former years by sapsuckers. All of these trees had ring shake in the annual ring that had been attacked by the birds.

Limited observations were made also on five species of northern hardwoods. Sapsuckers had girdled some hardwoods, had caused cankers on some others, and in still others injuries had been made in the annual ring that separated. The association of sapsucker injury with some ring shake seems to be established, but the exact role of these birds in relation to ring shake is not yet known.

Decay of Wood in Use

Decay developed rapidly in blocks of wood buried in soils infected with soil-inhabiting decay fungi. Treatment of infected soil with trichlorobenzene proved to be highly effective throughout a 21-month test period against the four important decay fungi: *Poria incrassata*, *P. vaillantii*, *Merulius lacrymans*, and *M. americanus*.

FOREST ECONOMICS

PRODUCTION ECONOMICS AND MARKETING

R ESEARCH in forest economics went forward in three principal areas during 1962.

- A study of the economics of white-pine weevil control neared completion. This is one of the major studies undertaken to develop pest-control and management guides for white pine growers in the eastern section of the country. Development of these guides is a major part of our research program in the economics of timber production.
- A study of the process by which firms in a number of timber industries select plant locations was completed. It was an important part of our work in the economics of industrial development.
- An informal effort to define more closely both the usefulness and limitations of economic analysis in forestry was continued.

Production Economics

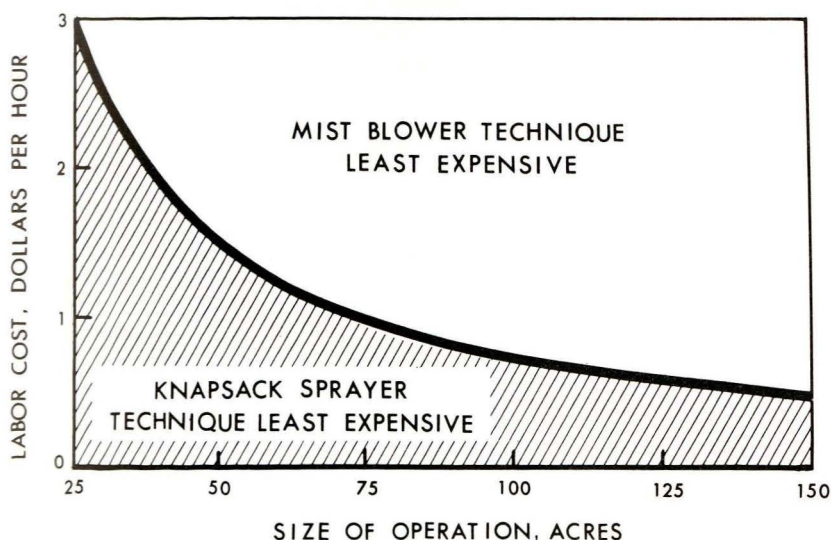
The main purposes of production economics are: (1) to evaluate the economic efficiency of production techniques, practices, and programs; and (2) to formulate management guides, based on these evaluations, for the practicing forester and public program director whose business it is to make forests efficient producers of economic goods and services. In this area of our research program we seek to interpret new forest practices and new economic conditions in terms of their economic potential and effect, and also to re-evaluate long-established practices and programs as better biological and economic data become available.

Our last year's Annual Report described research in a more basic phase of the production-economics project. During 1962 the major effort in this project was an analysis of the economics of white-pine weevil control in the Northeast. This analysis is built in part on data developed in an earlier economics study of blister rust control in the Lake States, and on a preliminary analysis of returns to weevil control in New York State pine plantations. It is an example of the way in which individual studies are meshed within a research project to

attain a stated project objective. The analysis draws heavily on research accomplished by our Division of Forest Insects Research and on the experience of cooperators in the Forest Service Cooperative Pest Control Program. It also illustrates integration of the programs of various research divisions within the Station, and cooperation on research of mutual interest with action units of both the Forest Service and state conservation departments.

The white-pine weevil (*Pissodes stribi* Peck) is an endemic insect pest on white pine (*Pinus strobus* L.). Adult weevils lay their eggs in the leaders of young pine, and when the grubs hatch they feed within the leader and kill it. Pines that have been injured repeatedly in this fashion become deformed and have less usable volume and yield lower quality lumber than uninjured trees. The white-pine weevil may be costing Northeast pine owners more than \$2 million each year in volume and quality losses. And so far this pest is largely uncontrolled.

Our study in the economics of weevil control is meant to answer three important questions for practicing foresters interested in this activity: *how* control can best be accomplished; *where* control is most profitably practiced; and *when* control should be initiated. Although at this writing the study is not yet complete, we have some preliminary results.



The influence of labor costs and size of area upon the choice of method for white-pine weevil control. The knapsack-sprayer is the obvious choice for small jobs.

Two effective control techniques are now available: the application of insecticides to pine leaders with a compressed-air knapsack-sprayer rig; and the broadcast application of insecticides to pine foliage with a mist-blower. The knapsack-sprayer method takes more time than a mist-blower technique, but the initial investment in equipment is much less. So the choice between these two techniques depends on labor costs and the number of acres over which control will be practiced. The knapsack-sprayer is the obvious choice for the small control job, but if control will involve more than 50 acres, and if labor costs are a factor, the mist-blower may be a better choice in the long run.

An analysis of the profitability of control under a range of conditions—high and low treatment costs, various rotation ages and harvest tree sizes, various degrees of weevil injury, one- and two-log controls, and a high and a low pine stumpage price level—indicates that the overriding factor that determines profitability is rotation age. Rotation age sets the length of time that control costs must be carried forward at compound interest before the associated return becomes available at harvest.

In addition to rotation age, tree size at harvest and control costs significantly influence returns. The rate of return to weevil control varies with several combinations of these factors (table 1). This information can be used to determine those stands where control could be undertaken most profitably.

Neither various degrees of weevil injury nor a considerable range in stumpage price seems to have much influence on profitability.

Table 1.—*Approximate rates of return to weevil control*

Harvest plans		Rates of return ¹	
Rotation age	Target d.b.h. for crop trees	Butt-log control	Second-log control
<i>Years</i>	<i>Inches</i>	<i>Percent</i>	<i>Percent</i>
60	12-14	7-8	7-9
60	10-12}	5-7	5-7
80	16-20}		
80	12-16}	4-6	3-5
100	14-26}		

¹ Appropriate only for public agencies because returns are based on total values added by control, and because tax considerations are not included. A cost per treatment of \$3 per 100 crop trees is assumed.

when this is measured by rate of return. Different levels of weevil injury have compensating costs and returns. Where weevil injury is light, little is saved by weevil control, but control is inexpensive; so one factor offsets the other. Similarly, where weevil injury is heavy, much is saved by control; but control costs are also higher.

Increases in stumpage price yield a less than proportional increase in the value of savings at harvest. More important, even large changes in control returns do not yield much change in the rate of return. A doubling of control return causes less than a 1-percent increase in rate of return when the investment period is 80 years, for example.

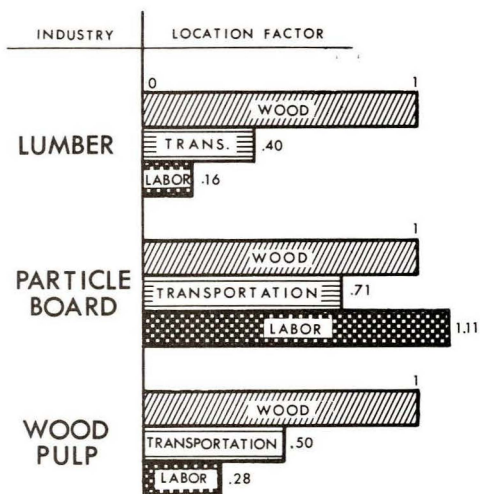
Interestingly, control of the second log with mist-blowers appears to be just as profitable, under similar conditions, as butt-log control. The reason for this is that although second-log control returns are less, control costs do not have to be carried forward as many years to harvest.

The final control question is one of timing. Control need not be initiated in young stands until potential crop-trees are in danger of damage. Where weevil hazard is light, and there is ample stocking, a sufficient number of well-distributed, uninjured pines for crop-trees may be available for a considerable length of time after weeviling begins, allowing control to be postponed for some years. When hazard is severe and stocking sparse, on the other hand, control must begin very soon after stand establishment in order for a sufficient number of pines to be maintained in a weevil-free condition. By choosing a minimum number of pines, needed for crop-trees, and by examining stands periodically, foresters can institute control as it becomes necessary—not too soon, and not too late.

The Location Decision

What factors determine the locations of wood-using plants and what is the relative importance of the various factors? The answers to these questions are important to local development agencies attempting to attract new industry. They are also important to policy-makers attempting to assess the long-run changes taking place in the wood-using industries.

A study was made of the location decisions for three primary wood-using industries in the northern Appalachians—lumber, particle board, and wood pulp. In location, all are generally classed as being oriented toward their raw material supply. However, other factors, both economic and noneconomic, also seem to be important. But just how important are they from the viewpoint of the decision-maker?



The relative importance of the factors considered by wood-using industries in selecting plant locations.

This study was directed at an evaluation of the relative importance of these factors.

It was found that, for the lumber industry, wood costs are the most important factor, followed at some distance by transportation to markets. For the particle-board industry, labor, wood, and transportation costs do not vary greatly. For the wood-pulp industry, wood costs are most important, followed by transportation, labor, and electricity costs, in that order. Other costs are relatively of much less importance.

It was also found that there is a substantial difference between lumber and wood pulp firms in the manner in which the location decision is made. For the typical lumber firm, the location is chosen first; then the nature of the raw-material supply determines the markets that will be entered. For the wood-pulp firm, the market decision is made first; then, a location is chosen that will enable the firm to compete in the selected markets.

The results of this study should be useful to development agencies and policy-makers in evaluating the suitability of particular areas for wood-using plants. The study also provides a basis for future work in the economics of location.

Usefulness of Economic Analysis

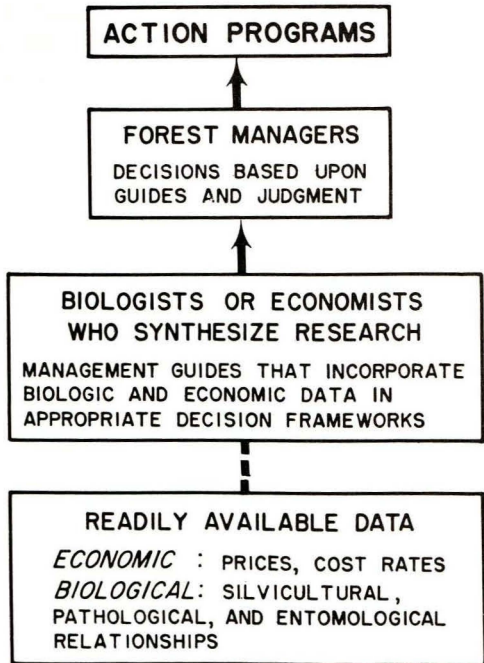
Our third major area of work was a continuing effort to define more closely both the usefulness and limitations of economic analysis. How it is useful and where are its limitations as a guide to managers

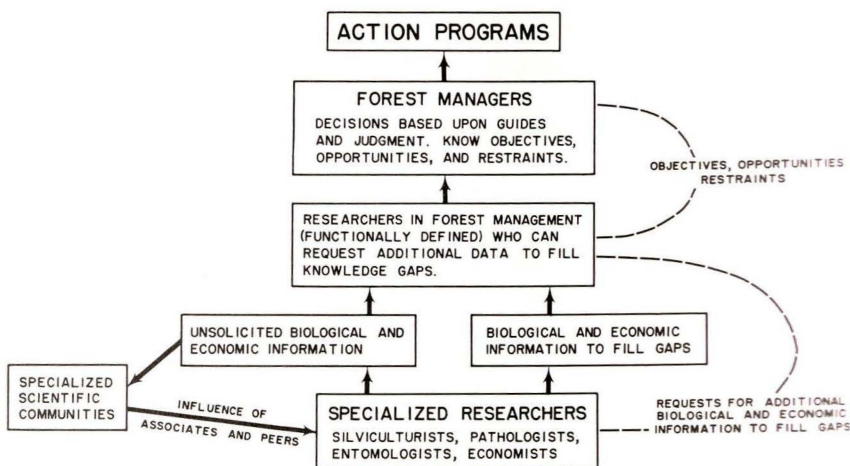
of forest land? Past efforts include the studies of uncertainty and its effects on timber-management decisions that were discussed in our 1961 Annual Report.

Work in this area took three forms during 1962. First, the relationship between forestry practice, biological research, and economic analysis was explored. Second, the potential usefulness of economic analysis in developing guides to watershed-management decisions was examined. And third, a timber-management case study was developed to define the usefulness and limitations of an earlier study of timber management opportunities in Pennsylvania.

Forestry practice is the concern of investors and practicing foresters. They make practical management decisions based on available information. For effective decisions concerning forestry practices, they need biological information, economic information, and appropriate frameworks for fitting this information together. Forestry researchers are specialists in the development of information. However, much forestry research is not directly useful to investors and practicing foresters because it is fundamental and often reported as much for its methodology as for its practical implications. Therefore, efforts to organize existing but scattered information and to undertake new research to fill gaps are potentially very valuable.

How forest management and research might be organized to meet simple situations.





How forest management and research might be organized to meet complex situations.

In this, economic analysis has a significant but not necessarily a dominant part to play. Either biological or economic researchers may be able to provide biological information, economic information, and an appropriate framework in some simple cases. In more complex cases, biological information will be the primary responsibility of biological researchers, economic information the primary responsibility of economic researchers; but for best results, the decision framework will likely be a joint undertaking even though economic researchers may have more direct interest in frameworks for decision.

Consideration of the potential usefulness of economic analysis in watershed-management decisions showed that there are essentially three kinds of decisions. There are least-cost decisions where the goal is to change the quantity, quality, or timing of water flows by a given amount and to do this as cheaply as possible. Then there are fixed-expenditure decisions where the goal is to spend a given budget in such a manner that the greatest possible benefit from changes in water flows is obtained. And finally there are production-goal decisions where the goal is to determine the budget for watershed management that will give the greatest net benefit. Obviously the discretion open to the land manager increases from least-cost to fixed-expenditure to production-goal decisions. When the necessary biological (or physical) data become available, conventional techniques of economic analysis can be used to provide guides to least-cost decisions and many fixed-expenditure decisions. These decisions do *not*

require measures of the value of water. On the other hand, production-goal decisions *do* require such measures. And, because water is rarely bought and sold by the unit at the watershed, economic analysis is not very useful in terms of guides to these decisions.

The timber-management case showed that this distinction between least-cost and fixed-expenditure decisions, on the one hand, and production-goal decisions, on the other, is broadly applicable even when products are commonly bought and sold by the unit. It showed that rates of return for a series of timber-management opportunities would provide a useful ranking. Any given budget could be spent more efficiently with the aid of such a ranking than would be the case without it. Rates of return (and other profit measures developed by economic analysis) appear to be much less useful in budget determinations. Here timber management must be compared with some extremely diverse activities. For example, in the case of state or federal programs, the relevant comparisons might be with education, highway construction, and mental health programs. Obviously it would be difficult to reduce the benefits of these activities to a common scale.

Progress on Other Studies

An informal study was made to develop a theoretical model for examining forest land use alternatives. This study identified the costs involved in shifting land from timber production to other uses such as developed recreation areas and closely restricted reservoir sites. It pointed out that major shifts in forest land use away from timber management are likely to result in either less timber or higher management costs on the remaining timber land or both.

Cooperation continued with six agricultural experiment stations on regional marketing research. This group will soon complete a project describing certain aspects of the structure of lumber markets in selected sections of the Northeast.

FOREST SURVEY

A major effort of the Forest Survey was a project to update Survey statistics to provide state and regional data on forest areas and timber volumes.

Similar data had been compiled about 10 years ago for inclusion in the Timber Resource Review. Since then there have been developments in the timber situation in many states that have affected both timber growth and timber cut.

Information on present and prospective timber supplies from this updating project will provide better guidelines for local evaluations

of industrial opportunities and will also provide a major part of the basic information needed for national program planning.

During the field season of 1962 we remeasured a sample of the initial survey plots in all states except those for which there are recent survey data. Regression equations will be developed by a high-speed electronic computer to update the resource statistics in 1963. These remeasured plots will be used not only to update statistics, but also to contribute data to the regular resurvey for each state or unit.

The resurvey of Maryland, started in 1961, is almost completed. Lack of new aerial-photo coverage in the two westernmost counties had delayed field work in those counties. Flying has now been completed, and the remaining plots in this area will be taken both by crews from the Maryland Department of Forests and Parks and from the Forest Survey. Compilation of field-plot data is already in progress and a report on the timber resources of the State will be prepared in 1963.

Another form of survey intensification took place in Washington County, Maine. Solution of the problem of substantial and persistent underemployment in this county requires fuller use of the timber resources. It has been estimated that 200 full-time job opportunities could be created through increased use of local timber. In order to plan for expansion of existing wood-using industries or encourage development of new ones, it is necessary to have accurate knowledge of the timber resources.

The Forest Survey of Maine, completed in 1959, does not provide sufficient detailed and precise resource information relating specifically to certain areas of Washington County. The most efficient way to obtain these data is to intensify the Forest Survey. The Area Redevelopment Administration made funds available, and all field work was completed this fall. Resource data and information will be compiled early in 1963.

A start on the Pennsylvania re-survey was made by the remeasurement of plots throughout the State as part of our regional updating project. In addition to this, we completed about one-third of our cooperative inventory with the Pennsylvania Department of Forests and Waters of the 1.8 million acres of State Forest lands. Data compilation is now in progress, and plans are under way for completing the field work on the remaining State-owned lands in 1963.

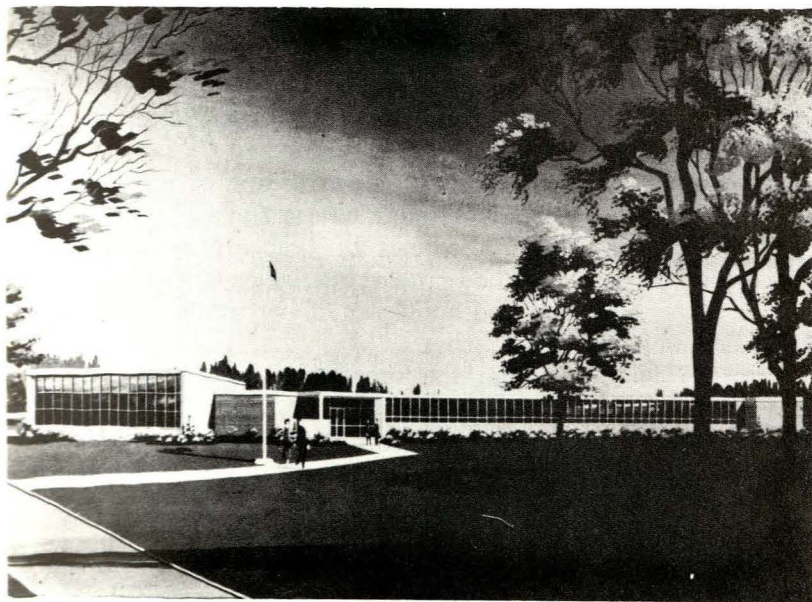


FOREST PRODUCTS MARKETING LABORATORY

Activities during the past year at the Station's new Forest Products Marketing Laboratory in Princeton, W. Va., were centered mainly around the planning and construction of research facilities, the development of a detailed program of research in the marketing of Appalachian hardwoods, and the compilation and analysis of marketing data collected in 1960 and 1961 prior to establishment of the Princeton Laboratory.

The primary objective of the Princeton program will be to develop information for the purpose of increasing the competitive position, and thereby the marketability, of wood and wood products of the Appalachian area. The program can therefore include studies of factors having influence on the orderly and efficient preparation, sale, and distribution of forest products for industrial or consumer use. This will ultimately lead to the expansion of timber-based industries and a corresponding increase in employment opportunities.

Construction work has progressed on schedule. A 13,000-square-foot office-laboratory building, designed by a Charleston architecture and engineering firm, is under construction and should be ready for



The new U. S. Forest Service research laboratory being constructed at Princeton, West Virginia.

occupancy early in June 1963. This building contains office space for scientists and clerical people, two multi-purpose laboratory rooms, library, conference room for 150 people, computing and drafting rooms, and other research facilities.

A second large building, the Methods Laboratory, is now being designed. It should be ready for occupancy by January 1964. This building will be the principal facility at the Experimental Wood Yard, where research will be conducted in the processing and manufacturing of wood products from Appalachian hardwoods. The Methods Laboratory will have a 10,000-square-foot test room, tool and supply room, combination lobby and display room, and a locker and lunch room for employees. Supplemental facilities will be added as the need develops.

Many of the Laboratory's studies will be conducted at the plants of industrial cooperators; other studies requiring special equipment, facilities, and technical personnel not available at the plants of commercial cooperators will be centered at this facility.

The primary responsibility of the four-man technical staff during the past year was to develop an overall forest-products-marketing research program for the laboratory. Work was also begun on the preparation of detailed study plans for several of the high-priority problems. Details of the program were developed with the consultation and advice of members of the forest-and-wood-products industry, university forestry schools, extension foresters, and various public and private agencies.

Because of the broad scope and complexity of the Princeton project, the proposed program has been divided into four areas of investigation: (1) market analysis; (2) harvesting and marketing primary forest products; (3) preparation and marketing of primary manufactured products; and (4) product testing and development. The planned program includes studies of timber harvesting, timber processing, timber and wood-product marketing systems, consumer use of timber products, and appraisals of opportunities for new or expanded wood-using industries.

Prior to final adoption, the proposed program of marketing research will be reviewed with the recently formed 18-member Forest Products Marketing Research Advisory Committee. This committee, composed largely of people active in the forest-products industry, will meet annually to review and advise the Station on the Princeton program.

Manuscripts were prepared or published in 1962 for three studies that provide background information for formulation of the Princeton program. One progress report of a study of opportunities for expanding of timber-based industries in West Virginia was published

early in 1962. This report, *Timber Industry Opportunities in the Beckley-Hinton Area of Southern West Virginia*, provides basic information and analysis that can be used by the timber industry, state and county agencies, and others actively engaged in efforts to expand industrial and commercial activities based on the timber resource. Opportunities for three primary wood-using industries (lumber, pulp, and particle board) and two secondary wood-using industries (flooring and furniture) were reported on. In general, the report shows that there are adequate timber, labor, water, and industrial sites for a sizable expansion of timber-based industries in the Beckley-Hinton area. This initial report covers only production factors.

Data collected in 1961 were analyzed for a report of wood residues and lumber available as raw material for wood-using industries in West Virginia. This study shows:

- Enough lumber is produced in West Virginia each year to supply a number of relatively large wood-using industries:
- The amount and grades of lumber available in each of the four areas investigated (Beckley-Hinton, Elkins, Huntington and Richwood) are suitable for a number of different kinds of wood-using industries, including furniture and flooring:
- A large quantity of hardwood residue is produced that is suitable for the charcoal, wood-pulp, and particle-board industries:
- A major portion of these wood residues were not being utilized at the time of the survey.

Results of a 1960-61 study of lumber purchased by 663 industrial users in North Carolina, Ohio, and Virginia indicated that 28 percent of the users were experiencing lumber procurement problems. Approximately 90 percent of the major complaints were based on non-conformance to specifications; that is, the users were receiving lumber that did not meet the purchase specifications. About one-half of all the complainants cited grade as the major cause of their dissatisfaction. Some 55 percent of the complainants also listed inaccuracy of manufacture as an important but secondary cause of dissatisfaction. Other complaints included delayed delivery, species nonconformity, unsatisfactory lengths, excessive price, and the mixing of grades in carload shipments. Further studies may be needed to verify, or explain, these findings.



FOREST UTILIZATION

NEW developments in the wood-using industries of the Northeast continued to appear in 1962. Lumbermen continued to invest in new and more efficient equipment in order to improve product quality and reduce costs. Although a slight increase in total timber products output for 1962 was apparent, white pine lumber production continued to decline, due to loss of markets for low grades; and several old-line white pine mills closed their doors for good. Some of the slack in pine production was taken up through increased production of other softwoods and hardwoods.

A number of new hardwood sawmills have come into production during the year and at least four new modern hardwood dimension operations have been set up. In addition, several modern hardwood veneer mills are in the process of getting into production in the region.

A finger-jointing operation has been set up in southern Maine to utilize low-grade white pine lumber. Recent reports on the installation indicate that commercial production of boards and panels is expected to begin early in 1963. The success of this operation should greatly improve the position of the white pine lumber industry in Maine and New Hampshire.

Production of pulp chips from sawmill residues continued to increase, particularly in the Pennsylvania-West Virginia area. The year also saw the closing down of a chipboard plant and sulfite pulp mill in the northern part of the region.

Our Division of Forest Utilization Research has been involved in the majority of these developments, assisting representatives of industry and development agencies in the application of research results, and planning new studies to obtain information needed.

Timber Harvesting

In a report prepared for the International Union of Forest Research organizations, we estimated that 50 percent of the hardwood logging and 20 percent of the softwood logging in the Northeast is now being done in tree lengths. In general, it appears that tree-length logging results in a 20 percent saving in logging costs, realized

through larger pay loads and considerably less skid-trail development.

Additional profits not included in the above figures can be realized through better volume and grade recovery when bucking is done at the roadside or mill yard. One company reported up to a 30 percent increase in volume of high-grade veneer logs when the bucking operation was shifted from the woods to the landing.

A report on *Applicability of Wheel Tractors to Logging* was presented by Fred Simmons at the National Forest Products Research Society meeting at Spokane in June 1962. This paper covered the results of about 10 years' experience with these machines in north-eastern logging operations. It also covered improvements in design of machines, methods of using them, and results attained on operations—including cost reductions, product quality improvement, and attainment of forest-management objectives.

Results of several other important research projects by other agencies were reported at the Eighth Northeastern Loggers Congress. These included a report on a simplified system of collecting logging cost-control data, developed on the Scott Paper Company operations in Maine; a report by a representative of the West Virginia Pulp and Paper Company on company studies of measurement of pulpwood by weight; and the results of an important study on log-trucking costs by a hardwood lumber producer in Pennsylvania.

Small Sawmill Improvement

Data continued to be accumulated on successful results attained from installation of live decks, pushbutton-operated carriages, edgers and trimmers, and complete conveyerization at relatively small sawmills. Mills that continue to use only the headrig for log breakdown are obtaining half again the production with only $\frac{1}{2}$ to $\frac{1}{3}$ the crew formerly needed for manually operated equipment. In many cases the excess personnel have been put to work in remanufacturing operations, most frequently in pallet manufacture or dimension-stock production. Mills that have installed sash gang or line bar resaws, in addition, are frequently more than doubling their previous production; at the same time they are obtaining greater quantity and quality recovery from the same type of logs that were accepted previously.

Wood Use Development

The Division cooperated with the Forest Products Laboratory in several wood-use studies in 1961-62. A final report was made by the FPL on the study of recovery of clear cuttings from standard

grade white pine in Maine and New Hampshire. The recovery of clear material from No. 4 Common at mills that cut second-growth stands in the southern and central part of the territory was just about equal to the recovery from an equivalent grade at mills that cut old-growth timber in the northern part of the area. Yields of clear material from 4- and 6-inch material in all sections was definitely lower than that obtainable from boards of 8-inch width and wider. Average yields of clear cuttings from the 4- and 6-inch wide material were around 50 percent, the 8-inch material around 60 percent, the 10-inch boards 65 percent, and the 12-inch 68 percent. The average yield of the entire sample was 59 percent in clear material of at least 3-unit size, equalling $\frac{1}{4}$ square foot surface measure.

A consulting engineering firm was assisted with recommendations for the location and facilities of a proposed new brush-block plant that would use approximately 3 million board feet of 3-A and No. 2 Common beech annually. A location in northern West Virginia, western Maryland, or southwestern Pennsylvania seemed most desirable.

Timber Quality

Field data for the Southern Appalachian and Lake States white pine log-grade studies completed in 1962 are now being processed by the Northeastern station. Preliminary results indicate that log values for grades 1 and 2 are lower in the Appalachian area than in the Northeast, but values appear to be the same for log grades 3 and 4. This is apparently due to the occurrence of more red rot in the older growth pine sampled in the Appalachian area. It is suspected that a similar relationship exists in the Lake States. If such proves true some modification of the trial grade specification may be required.

A 10-percent interest on the investment for pruning (30 cents per tree over an 11-year period) was realized on a sample of 38 pruned white pine trees sawed at the Pack Demonstration Forest sawmill at Warrensburg, New York. It should be noted that although diameter growth during the period averaged only 2 inches, the increase in value due to pruning was well justified. The average increase in value per tree for seven fast growing white pine trees included in the Appalachian grade study was \$11.98. This amounted to an interest return of 20 percent compounded annually for the 21-year period involved. Average diameter growth for these trees was about 10 inches. Additional studies of pruned white pine trees are planned for the coming year.

Personnel

Fred Simmons retired from the Forest Service on July 31, after 30 years of service. On August 1, he enplaned for Santiago, Chile, on a 3-year contract with the Food and Agriculture Organization of the United Nations. Fred is serving as a senior advisor to the Chilean government on the development of the sawmilling and mechanical wood conversion industries.

Dr. Richard N. Jorgensen was appointed as successor to Mr. Simmons in the Division of Forest Utilization Research at the Northeastern Station, effective January 1, 1963.

The Station collaborated with Region 7 on a third black cherry grade-yield study conducted in central New York. This completed the work programmed for the species. Data is being analyzed at the Central States Station by the hardwood section of National Log Grade Project. Grade-yield data for black cherry is scheduled for publication early in 1963.

Preliminary analysis of the field data for the tree grade and volume study conducted in West Virginia (reported in 1961) is now being done at Iowa State University by Dr. Kenneth Ware.

Other Activities

Division personnel continued to be active in affairs of the Forest Products Research Society, the Northeastern Loggers' Association, the New England and Keystone Kiln Drying Associations, and similar organizations.

The Division continued to participate in numerous log-grading and sawmill training sessions sponsored by Federal, state and industrial organizations throughout the area.



PUBLICATIONS

in 1962 by staff members and cooperators of the Northeastern Forest Experiment Station, Forest Service, U.S. Dept. of Agriculture.

General

Bickford, C. Allen.

1962. Some uses of statistics for industrial forest managers.

South. Lumberman 205 (2561): 110-112.

Principles of administrative use of statistics are presented and discussed in relation to forest industry. An illustration from use of stratified sampling in a timber cruise is described.

Bickford, C. Allen.

1962. Methods of measuring the growth of trees as individuals and in stands. In *Tree Growth*, 371-384. Ronald Press, New York, 442 pp.

Choice of the best way to measure growth for a given purpose is often difficult. The relative merits of the various methods are discussed to guide the forest manager.

*Northeastern Forest Experiment Station.

1962. Annual report 1961.

U.S. Forest Serv. Northeast. Forest Expt. Sta., 98 pp., illus.

A summary of research activities and accomplishments in forest management, watershed management, forest insects, forest diseases, forest economics, and forest utilization. Annotated list of publications.

Forest Management

*Blum, Barton M., and Filip, Stanley M.

1962. A weeding in ten-year-old northern hardwoods—methods and time requirements. U.S. Forest Serv. Northeast. Forest Expt. Sta. Forest Res. Note 135, 77 pp., illus.

Information on treatment costs is necessary in judging the feasibility of cultural operations. An equation relating weeding time in man-hours to number of crop trees released per acre was developed for 10-year-old northern hardwood patch cuttings. Crew organization and weeding procedures are also discussed.

Curtis, Robert O., and Post, Boyd W.

1962. Site-index curves for even-aged northern hardwoods in the Green Mountains of Vermont. Univ. Vt. and Vt. Agr. Coll. Bul. 629, 11 pp. illus.

A tree-stem analysis method was used to develop site-index curves for

* Copies or reprints available from the Northeastern Forest Experiment Station, U.S. Forest Service, 102 Motors Avenue, Upper Darby, Pa.

white ash, sugar maple, yellow birch, and white birch growing on acid glacial till in the Green Mountains.

*Curtis, Robert O., and Post, Boyd W.

1962. **Comparative site indices for northern hardwoods in the Green Mountains of Vermont.** U.S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 171, 6 pp., illus.

Equations were developed to express relationships among site indices of white ash, hard maple, yellow birch, and white birch. Given the site index of one species, the site indices for the other three species can be determined.

Davis, Grant.

1962. **Testing hybrid poplars on strip-mine banks in the Bituminous Region of Pennsylvania.** U.S. Forest Serv. Region 7 State Nurserymen Conf. Proc.: 50-53.

Two-year results from a planting study with 62 clones indicate that hybrid poplars generally do well on soils that are less acid than pH 4.0. Growth and survival are under observation.

Davis, Grant.

1962. **The place of chemical growth regulators in nursery management.** U.S. Forest Serv. Region 7 State Nurserymen Conf. Proc.: 55-58.

Gibberellic acid had no practical effect upon production of white pine, Norway spruce, and Japanese larch. Light concentrations of maleic hydrazide prolonged the dormancy of Japanese larch planting stock and resulted in better height growth.

Davis, Grant, and Melton, Rex E.

1962. **Plantations on strip-mine banks can yield timber products.** Pa. State Forest School Res. Paper 29, 2 pp.

In the Bituminous Region of Pennsylvania, an examination of 25-year-old plantations showed that Scotch pine, Japanese larch, and white pine are potentially good timber producers on strip-mine banks. Eight other species in the study should produce some timber.

Doolittle, Warren T.

1962. **Mining's second crop.**

Izaak Walton Mag. 27 (11): 14, illus.

Old, barren strip-mine banks and current strippings pose very difficult planting problems in Pennsylvania's Bituminous Region. In 1958, a cooperative research project of federal, private, and state organizations was initiated to seek solutions to these problems.

*Fenton, Richard H.

1962. **Meadow mice prefer Virginia pine.**

Jour. Forestry 60: 258-260, illus.

Meadow mice showed a definite preference for Virginia pine over loblolly pine in a 5-year-old mixed planting in Maryland; one-third of the Virginia pines were completely girdled as compared to 3 percent of the loblolly.

*Filip, Stanley M., and Leak, William B.

1962. **Profitable woodlot management in New England.**

U.S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 170, 17 pp., illus.

Records from two northern hardwood woodlots in New Hampshire showed that an old-growth woodlot can pay an immediate profit regardless of whether the owner sells stumpage, hires labor, or does his own work.

Gabriel, William J.

1962. Experience with black polyethylene film for mulching hardwood transplants. U.S. Forest Serv. Tree Planters Notes 51: 25-29, illus.

At an experimental nursery in Vermont, growth, survival, and weed control were satisfactory when seedlings were mulched with 0.015 mm. black polyethylene film. Cautions on use to prevent development of multiple stems.

Gabriel, William J.

1962. Inbreeding experiments in sugar maple (*Acer saccharum* Marsh.)—early results. Northeast. Forest Tree Improve. Conf. Proc. 9: 8-12.

A study at Burlington, Vt., showed that seed set of sugar maple following self-pollination varied between trees and was consistently less than under cross-pollination. Selfed progenies were extremely variable and exhibited some unusual characteristics such as albinism and colored cotyledons.

McQuilkin, W. E., and Strickenberg, L. R.

1962. Roadside Brush Control.
Plants & Gardens 17 (4): 23-26, illus.

After studies of mowing vs. chemical control, the U.S. Forest Service has adopted selective spraying with 2,4,5-T in oil as standard practice for roadside brush control in the eastern national forests.

McQuilkin, W. E., and Strickenberg, L. R.

1962. Brush control in practice on the national forests.
In *What's happening along our roadsides?* Conn. Arboretum Bul. 13: 3-12, illus.

See above.

*Marquis, David A., and Yelenosky, George.

1962. A chemical light meter for forest research.
U.S. Forest Serv. Northeast. Forest Expt. Sta., Sta. paper 165, 25 pp., illus.

Detailed instructions on procedures and equipment for prospective users of the chemical light meter, a method based upon the polymerization rate of anthracene (in benzene) into insoluble dianthracene, which depends upon the cumulative amount of light exposure.

Mills, Brooks B.

1962. The Beddington burn stages a comeback.
Forest World 1 (3): 49-51.

The severe 1952 Beddington burn in southeastern Maine now supports excellent reproduction of aspen and birch with an understory of softwoods—principally balsam fir.

*Phillips, J. J.

1962. Some effects of competition on the survival of yellow-poplar seedlings. U.S. Forest Serv. Northeast. Forest Expt. Sta. Forest Res. Note 134, 4 pp.

Past attempts to reproduce yellow-poplar in New Jersey have often failed. Study results showed that the 3-year survival of yellow-poplar seedlings is favored by an overstory density of 50 percent or less, a minimum of understory competition, prompt seedling establishment after cutting, and a first-year height growth of more than 2 inches.

Rushmore, Francis M.

1962. Maine's forest-based recreation.

Maine Forester 1962: 33-34.

Because of abundant recreation resources and reasonable proximity to population centers, Maine could capitalize upon the growing demand for outdoor recreation. Opportunities and possible courses of action are discussed.

*Santamour, Frank S., Jr.

1962. Chromosome number in striped and mountain maples.

Rhodora 64: 281-282.

Chromosome counts for striped and mountain maples consistently gave $n = 13$ with no meiotic irregularities. Both species appear to be diploid over the northern portions of their ranges.

Santamour, Frank S., Jr.

1962. The chromosome number of *Quercus dentata*.

Morris Arboretum Bul. 13: 28-30, illus.

Previously reported as a tetraploid, *Quercus dentata* Thunb. was found to be a diploid with $n = 12$, $2n = 24$ chromosomes. High pollen sterility and large pollen-grain size may have been responsible for the tetraploid interpretation.

Santamour, Frank S., Jr.

1962. A natural hybrid between *Pinus Griffithii* and *P. parviflora*.

Morris Arboretum Bul. 13: 51-53, illus.

Taxonomic features were used to identify a well-formed and vigorous natural hybrid between Himalayan and Japanese white pine. Further studies will determine crossability patterns for this hybrid.

*Santamour, Frank S., Jr.

1962. The relation between polyploidy and morphology in white and biltmore ashes. Torrey Bot. Club Bul. 89 (4): 228-232.

Within a group of young trees designated as *Fraxinus americana* it was possible to separate tetraploids and hexaploids from diploids on a morphological basis. Diploids were typical white ash; polyploids were assigned to *F. biltmoreana*, a separate species.

Schreiner, Ernst J.

1962. Objectives of pest-resistance improvement in forest trees and their possible attainment. World Forestry Cong. Proc. 5: 721-727.

Basic information is needed on variation, inheritance, environmental effects, pest life cycles, and causes of resistance; but meantime empirical breeding work for pest resistance can and should proceed. Discusses possible tree-improvement approaches and the need for international cooperation.

Schreiner, Ernst J.

1962. Clonal or seedling seed orchards.

Northeast. Forest Tree Improve. Conf. Proc. 9: 53-57.

Experience with clonal cinchona orchards in Java as well as theoretically determined genetic gains indicate that clonal seed orchards are inferior to seedling seed orchards for improvement possibilities.

*Schreiner, Ernst J., Littlefield, E. W., and Eliason, E. J.

1962. **Results of 1938 IUFRO Scotch pine provenance test in New York.** U.S. Forest Serv. Northeast Forest Expt. Sta., Sta. Paper 166, 23 pp., illus.

Evaluation of an 18-year-old planting of 43 seedlots. Growth was slow for the extremely northern provenances and high elevations. Seedling needle length was highly correlated with subsequent volume per acre but seedling height did not provide a very accurate guide to subsequent height growth.

*Snow, Albert G., Jr., and May, Curtis.

1962. **Rooting of Virginia pine cuttings.**

Jour. Forestry 60: 257-258, illus.

Study results showed that rooting is better for cuttings taken from the lower rather than upper crown positions, gathered in early rather than late winter, and treated with indolebutyric acid. Effect of day length was not established.

*Sucoff, Edward I.

1962. **Potassium, magnesium, and calcium requirements of Virginia Pine.** U.S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 169, 16 pp., illus.

A study conducted in automatically irrigated sand cultures in a greenhouse provided information on the minimum requirements of Virginia pine seedlings, deficiency symptoms for potassium and magnesium, and growth in relation to needle concentrations of potassium and magnesium.

Toole, Vivian K., Toole, E. H., Borthwick, H. A., and Snow, A. G., Jr.

1962. **Responses of seeds of *Pinus Taeda* & *P. strobus* to light.**

Plant. Physiol. 37 (2): 228-233.

Partially after-ripened seeds of loblolly and white pine germinated after brief exposure to red light. The effects of red and far-red light were reversible. Continuous light or repeated exposures shortened the required stratification period.

Trimble, George R., Jr.

1962. **Good and bad in logging.**

Northeast. Logger 11 (3): 18, illus.

A personal demonstration on the Fernow Experimental Forest convinced one operator that a good logging-road system means cheaper logging as well as adequate watershed protection.

*Wagar, J. Alan.

1962. **The convection stack—a device for ridding pit toilets of bad odor.** U.S. Forest Serv. Northeast Forest Expt. Sta. Forest Res. Note 133, 6 pp., illus.

A flame-actuated convection stack was developed to provide a safe and inexpensive way to eliminate foul smells from pit toilets in outdoor recreation areas.

*Yawney, Harry W.

1962. **2,4,5-T amine not recommended for frill-treating hardwood culls in West Virginia.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Forest Res. Note 128, 4 pp.

Dilute amine solutions of 2,4,5-T at 8 and 16 ahg were applied to cull hardwoods of 11 species and varying sizes. Kills after the third growing season were mediocre. Other studies indicate that 2,4,5-T ester gives somewhat better results.

*Yawney, Harry W.

1962. **Control of rhododendron by basal spray.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Forest Res. Note 132, 7 pp. illus.

Of four methods to control rhododendron studied on the Fernow Experimental Forest, stem-cutting and stump-spraying with 20-pound ahg 2,4,5-T in diesel oil, and basal spraying with the same mixture both proved highly effective; but both are too expensive for large-scale use.

Watershed Management

*Hart, George, Leonard, Raymond E., and Pierce, Robert S.

1962. **Leaf fall, humus depth, and soil frost in a northern hardwood forest.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Forest Res. Note 131, 3 pp.

Annual leaf accumulation under a second-growth northern hardwood forest in New Hampshire averaged 2,820 pounds per acre. In the mound-and-depression microtopography typical of the region, greater leaf accumulations and humus were found in the depressions, which insulated them against concrete frost.

*Lull, Howard W.

1962. **Management for water production on municipal watersheds.** World Forestry Cong. Proc. 5: 1686-1690.

Few, if any, of the forested municipal watersheds in the United States are now being managed to regulate water yield, yet increasing demands for water indicate need for such management. Possible approaches are suggested. Logging methods, erosion control, and pros and cons of recreation on watersheds are discussed.

Lull, Howard W., and Fletcher, Peter W.

1962. **Comparative influence of hardwood trees, litter, and bare area on soil-moisture regimen.** Univ. Mo. Agr. Expt. Sta. Res. Bul. 800, 15 pp., illus.

Report of a study in a mixed oak-hickory stand where pairs of plots were treated to obtain the following conditions: trees and litter (no treatment), trees only, litter only, and bare. Daily soil moisture readings were taken to establish the soil moisture regimen. Watershed implications are examined.

Lull, Howard W., and Rushmore, Francis M.

1962. **Influence of forest cover on snow and frost in the Adirondacks.** Eastern Snow Conf. Proc. 1961-62: 71-79, illus.

Maximum accumulation of snow-water in mid-March 1959 in a northern

hardwood stand was 9.01 inches as compared to 6.92 inches in a red spruce-balsam fir stand, but by mid-April the greater melt rate in the hardwoods had more than erased this 2-inch difference. Maximum accumulation and rates of melt were related to canopy closure as measured with a spherical densiometer.

Lull, Howard W., and others.

1962. **Forest land management in watershed programs. Chapter III (23 pp.) in Watershed management.** FAO Occas. Paper 13. Rome.

The protective function and water-yield effects of forest management on streamflow are discussed in respect to reforestation, logging, fire, disease, and insect attack. Watershed-management techniques are described in terms of general principles, and examples are given of applications to several environmental situations.

*Northeastern Forest Experiment Station.

1962. **Proceedings: watershed management research conference on collection and compilation of streamflow records.** U.S. Forest Serv. Northeast. Forest Expt. Sta., 55 pp.

Report on a conference held to review present methods of collecting and compiling streamflow data, to learn about recently developed machine methods for handling data, and to compare costs. Pending stronger justification for use of machines, present methods will be continued.

Reinhart, K. G., and Eschner, A. R.

1962. **Effect on streamflow of four different forest practices in the Allegheny Mountains.** Jour. Geophys. Res. 67: 2433-2445, illus. After a 6-year calibration period, four watersheds were cut over with practices ranging from a commercial clearcutting to a light selection cutting. Annual streamflow increased with intensity of cutting. Effect on water quality was related directly to degree of care taken in logging and skidroad planning.

Reinhart, Kenneth G., and Trimble, George R. Jr.

1962. **Forest cutting and increased water yield.** Jour. Amer. Water Works Assoc. 54: 1464-1472, illus.

Cutting four watersheds at the Fernow Experimental Forest in West Virginia gave increases in annual streamflow, depending on the amount of timber removed, ranging from 140,000 to 8,000 gallons per acre. With regrowth of vegetation, 4 years after cutting the increases had almost disappeared.

Forest Insects

*Dowden, Philip B.

1962. **Parasites and predators of forest insects liberated in the United States through 1960.** U.S. Dept. Agr. Agr. Handb. 226, 70 pp. A comprehensive listing of all liberations of parasites and predators for control of major forest insect pests in the U.S. through 1960, by host species; gives separate lists of parasites and predators that have been successfully established.

*Hastings, Arthur R., and Risley, John H.

1962. **White-pine weevil control with knapsack mistblower.**

U.S. Forest Serv. Northeast Forest Expt. Sta., Sta. Paper 167, 7 pp.
Tests made in New York State in 1956-60 indicate that the portable knapsack mistblower has real promise for practical control of the white-pine weevil, now the major insect enemy of white pine in the Northeast. Lindane and Malathion, alone and with an extender (Aroclor 5460), were the toxicants used.

Keller, J. C., Pascek, E. C., Hastings, A. R., and Johnson, V. A.

1962. **Insecticide tests against gypsy moth larvae.**

Jour. Econ. Ent. 55: 102-105.

Lists the chemicals tested and the methods used to assess their effectiveness. DDT served as the standard for comparison. Several insecticides gave as high an initial kill and/or residual effectiveness as DDT.

*Rollinson, W. D., and Lewis, F. B.

1962. **How to collect and process large polyhedral viruses of insects.**

U.S. Forest Serv. Northeast Forest Expt. Sta. Forest Res. Note 130, 6 pp., illus.

Describes the occurrence and importance of pathogenic viruses in natural populations of forest insects and gives evidence of their present and potential use for direct control of insect pests. Tells how to collect diseased insects and prepare the purified polyhedra powder.

*Shigo, Alex L.

1962. **Another scale insect on beech.**

U.S. Forest Serv. Northeast Forest Expt. Sta., Sta. Paper 168, 13 pp., illus.

Describes a scale insect [tentatively *Xylococculus betulae* (Perg.) Morrison] that causes a type of bark roughening commonly seen on American beech, and points out the differences in bark injuries caused by this insect and those caused by the beech bark disease.

Waters, William E.

1962. **The ecological significance of aggregation in forest insects.**
Internatl. Cong. Ent. (Vienna) Proc. Bd. II: 205-210.

The ecological and statistical elements involved in measuring and evaluating aggregation are discussed and their interactions are reviewed critically. A mathematically valid, ecologically meaningful, and easily computed measure of aggregation is described.

*Waters, William E.

1962. **Uninjured trees—A meaningful guide to white-pine weevil control decisions.** U.S. Forest Serv. Northeast Forest Expt. Sta. Forest Res. Note 129, 4 pp., illus.

Rather than the conventional measure of damage by percentage of trees injured, a new damage index is suggested—the number of trees remaining free of weevil injury. This puts the factor of allowable damage directly in terms that can be used and interpreted by the forest or plantation manager.

Forest Diseases

Brandt, Robert W.

1962. Observations and recommendations for a disease prevention program for American conifers in Yugoslavia. U.S. Agency Internatl. Devlpmt., 49 pp. Yugoslavia.

Report of a 4-month study of diseases of American coniferous species growing in Yugoslavia, with emphasis on diseases of eastern white pine and Douglas-fir.

*Dermen, Haig, and Diller, Jesse D.

1962. Colchiploidy of chestnuts.
Forest Sci. 8: 43-50, illus.

Tetraploid forms of American, Japanese, and Chinese chestnuts were produced by application of colchicine to buds just beginning to expand in the spring, in the search for trees resistant to chestnut blight.

Diller, Jesse D.

1962. Preventing underfloor dampness in buildings without basements. Natl. Acad. Sci.-Natl. Res. Council Bldg. Res. Inst. Pub. 986: 38-42, illus.

Reviews the use of ground covers to safeguard subfloor timbers of basementless houses from wood decay. Roll-roofing ground covers of 55- and 90-pound weights are still effective after 20 years of use.

Diller, Jesse D.

1962. Host resistance to the chestnut blight fungus *Endothia Parasitica*. North. Nut Growers Assoc. Ann. Rpt. 1961: 32-34.

American chestnut scions grafted in the top third of the crowns of Chinese and Japanese chestnut trees are still free of chestnut blight after 5 years. The question is whether a blight-resistance substance could have been transferred from the rootstock to the grafts.

Diller, Jesse D.

1962. Differentiation of three *Atropellis* species, based on gross cultural characteristics. (Abstract.) Phytopath. 52: 1217-1218.

Three species of *Atropellis* grown on malt agar in petri dishes made their maximum growth at 20°C. One was completely inhibited at 25°C., another at 30°C., but the third still exhibited slight growth at 30°C.

Diller, J. D., and Koch, E. J.

1962. Further studies concerning the spread of "house-decay" fungi through soil to living trees. (Abstract.) Phytopath. 52: 163-164.

From dissection of trees growing in an area inoculated with *Poria incrassata*, it was concluded that this fungus seldom spreads through the soil to standing timber.

Fowler, Marvin E.

1962. Appraisal of oak wilt control measures.
East. Plant. Bd. 37th Ann. Mtg. Min.: 22-36.

Interim report on an evaluation of oak wilt control methods. Notes reduction in oak wilt spread, but cautions against drawing conclusions from incomplete data.

Fowler, Marvin E.

1962. **Post-control appraisal report for 1961.**

Oak Wilt Conf. Proc. 1961 (Bedford, Pa.), 11 pp.

An evaluation of the effectiveness of oak wilt control measures, based on data from Central States, Northeastern, and Southeastern Forest Experiment Stations, with a caution against prematurely drawing conclusions.

Fowler, Marvin E.

1962. **Two diseases of sugar maple in the Northeast.**

U.S. Agr. Res. Serv. Conf. Maple Prod. Proc. 5: 43-45.

Maple dieback and an unnamed canker disease are causing death of sugar maples in the Northeast and Lake States. Researchers have not yet been able to find the causes of these diseases, though maple dieback seems to be associated with defoliation and climatic conditions.

Hepting, George H., and Fowler, Marvin E.

1962. **Tree diseases of eastern forests and farm woodlands.**

U.S. Dept. Agr. Inf. Bul. 254, 48 pp., illus.

Describes and illustrates major diseases in eastern forests and farm woodlands, and where known, recommends control measures. Contains indices to host trees and diseases.

Houston, D. R.

1962. **Stem cankers of northern hardwoods.**

Wis. Conserv. Dept. Forest Pest Leaflet 3, 4 pp.

Discusses briefly the causes and types of stem cankers and the damage they do. Describes symptoms, disease cycles, and control of *Nectria* canker of hardwoods, *Strumella* canker of oaks, and *Eutypella* canker of maples.

Houston, David R.

1962. **Maple blight—a problem of sugar maple initiated by defoliation.** U.S. Agr. Res. Serv. Conf. Maple Prod. Proc. 5: 42-43.

Describes search for cause of this condition, first observed in 1957, in Wisconsin. Isolations from diseased trees have produced no known pathogens, but defoliation—aggravated by climate and root rot—seems to be associated with the blight.

Houston, D. R., and Kuntz, J. E.

1962. **The Etiology of Maple Blight. (Abstract.)**

Phytopath. 52: 14.

This disease of sugar maples—characterized by terminal dieback; small, sparse, chlorotic leaves; formation of branch and bole sprouts; and sometimes death—was first noticed in 1957 in areas of northeastern Wisconsin where defoliation by insects had occurred. Typical symptoms developed the year following one artificial defoliation of healthy sugar maple saplings.

Shigo, Alex L.

1962. **Fungi isolated from discolorations in northern hardwoods. (Abstract.)** Phytopath. 52: 1221.

Hypoxylon spp., *Phialophora* spp., *Trichocladium* sp., and *Cytospora* sp. were the fungi most frequently isolated from the discolorations behind logging wounds and branch stubs on northern hardwoods. *Hypoxylon* spp. were the principal fungi infecting the sapwood through logging wounds. Bacteria were frequently isolated along with the fungi.

*Shigo, Alex L.

1962. Observations on the succession of fungi on hardwood pulpwood bolts. U.S. Dept. Agr. Plant Dis. Rptr. 46: 379-380, illus.

Examination of pulpwood bolts showed that *Ceratocystis coerulescens* is an important staining fungus and is usually the first fungus to become established on the cut ends of pulpwood bolts.

Shigo, Alex L.

1962. Logging wounds on northern hardwoods.

Forest Notes 75: 12-13, illus.

On residual trees wounded during logging operations the depth and location of wounds are reported to be more important than size alone in relation to subsequent decay and discoloration. Rate of fungus invasion and decay was influenced by time, type, and position of wound and other tree defects.

*Shigo, Alex L.

1962. Decays and discolorations in northern hardwoods.

Forest Notes 76: 17-19, illus.

A brief non-technical account of decays and discolorations in northern hardwoods with particular emphasis on infection courts, and the damage resulting from infection by fungi. Some results from studies being conducted in the White Mountains of New Hampshire.

Forest Economics

Christensen, Wallace W., Webster, Henry H., Baker, Gregory, Norton, Newell A., and Reid, William H.

1962. Marketing of Lumber produced by sawmills in the Northeast—phase I. W. Va. Univ. Agr. Expt. Sta. Bul. 478, 32 pp., illus.

This study, the first phase of a cooperative project to describe the structure of lumber markets in selected sections of the Northeast, deals with the role of lumber manufacturers in terms of the products they sell and the services they provide.

Dowdle, Barney.

1962. Investment theory and forest management planning.

Yale Univ. School Forestry Bul. 67, 63 pp., illus.

Proposes a modification of traditional forestry investment theory in which both maximum economic returns and explicit allowances for risk are considered. Identifies an efficiency frontier between the expected rate of return and the expected variance of returns. In an empirical example the modified theory is applied to determination of the rotation age for eastern white pine.

*Hagenstein, Perry R., and Dowdle, Barney

1962. A theoretical model for examining forest land use alternatives.

Jour. Forestry 60: 187-191, illus.

Interprets a simple economic model applied to broad aggregative decisions concerning alternative forest land uses. Identifies the nature of opportunity costs involved in these decisions.

Marquis, Ralph W.

1962. **A new approach to small woodlands.**

Pa. Forests 52 (1) : 11, illus.

A review of "Ten-year earnings from two small woodlands," by Wilfred C. Mitchell and Henry H. Webster (Station Paper 145, 1961), citing "its realistic approach to small ownerships, development of methodology for computing returns, and its disclosure of the big part that improved quality plays in producing earnings during the early years of a management program."

*Ware, Kenneth D., Bickford, C. Allen, Wilson, Robert W. Jr., and Mayer, Carl E.

1962. **A program for regression analysis with the IBM 650 electronic computer.** Jour. Forestry 60: 645-646.

Furnival's computer program for multiple regression analysis, developed for the IBM 650, is described. What can be done is explained as well as what is required in the way of data.

Ware, Kenneth D., and Cunia, Tiberius.

1962. **Continuous forest inventory with partial replacement of samples.**

Forest Sci. Monog. 3, 40 pp., illus.

The theoretical basis for using simple random sampling at the second of two occasions is derived, explained, and illustrated with respect to successive forest inventories. The place of sampling with partial replacement in planning the most efficient inventory is described.

Webster, Henry H.

1962. **How good are timber-management opportunities in Pennsylvania?** Pa. Forests 52 (2) : 20-21, illus.

An evaluation of opportunities for increasing timber values from the viewpoint of forest-land management agencies, notably the Pennsylvania Department of Forests and Waters.

*Webster, Henry H., and Hagenstein, Perry R.

1962. **Timber industry opportunities in the Beckley-Hinton area of southern West Virginia.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Misc. Pub., 29 pp., illus.

A report on a study to provide basic information and analyses that can be used by the timber industries, state, county agencies, and others engaged in efforts to expand industrial and commercial activities based on the timber resources.

Forest Utilization

Hampf, Frederick E., and Marty, Robert J.

1962. **New Hampshire pine-chip production.**

Northeast Logger 10 (12) : 18-19, illus.

Presents data on pine sawmill residue and chip production in New Hampshire, showing that most residue still goes unused but that increasing amounts of pine chips for pulping are being produced from residues. Briefly discusses possible future trends in New Hampshire chip production.

*Longwood, Franklin R.

1962. **Present and potential commercial timbers of the Caribbean.**

U.S. Dept. Agr. Agr. Handb. 207, 167 pp., illus.

Thousands of different wood species are available in Caribbean forests, but only about 20 are exported. Lack of knowledge, particularly by the consumer, is the main deterrent to expanded utilization. This handbook provides information on 71 timber species.

*Longwood, F. R.

1962. **The selection, design, and analysis of wildlife-habitat studies.**

Northeast Fish and Wildlife Conf., 11 pp.

Discusses considerations in selection, design, and analysis of research projects, with emphasis on need for careful planning.

Marquis, Ralph W.

1962. **Utilization and marketing of West Virginia hardwoods.**

W. Va. Governor's Conf. Wood Util. Proc.: 75-80.

A general review of the forest resources of West Virginia, with reference to wood utilization by manufacturing industries, and possibilities for expansion of timber industry in the State, and an outline of plans for the U.S. Forest Service forest products marketing research project at Princeton, W. Va.

Simmons, Fred C.

1962. **Advantages of log barking to the sawmill operator.**

Timber Producer 18 (2): 2.

Describes financial and other benefits from the use of log barkers in sawmills of various sizes, and discusses conditions necessary for undertaking a residue chipping program, including costs, limitations, and variables.

Simmons, Fred C.

1962. **Basic equipment required for wood processing in West Virginia.**

W. Va. Governor's Conf. Wood Util. Proc.: 56-65.

Describes newest types of equipment and operation methods suitable for processing West Virginia forest products, with special attention to lumber, pallets, dimension stock (including glued-up stock), and short-log bolter mills.

Simmons, Fred C.

1962. **Hardwood market requires better logging practices.**

Forest Industries 89 (11): 37, illus.

The wide price spread between high and low quality lumber grades makes the production of as much high-grade material as possible an economic necessity. Only 50 percent of the high-grade wood cut now gets into high lumber grades; logging practices are partly responsible.

Simmons, Fred C.

1962. **How the producer can log hardwoods more profitably.**

Forest Industries 89 (11): 66-67, illus.

Describes improved methods of felling, skidding, bucking, loading, and storage that logging operators have used to increase value yields and reduce logging costs. Diagrams of bucking practices to increase quality yield.

Simmons, Fred C.

1962. **The interrelation and comptability (sic) of silviculture and logging.** *In* Proceedings of three symposia on wood quality. Ontario (Canada) Dept. Lands and Forests Res. Rpt. 48 (Ontario Res. Found. Rpt. 601) : 17-20.

The economics of logging are not always compatible with silvicultural practices. New methodology and equipment help make it easier to formulate the necessary compromises.

Simmons, Fred C.

1962. **Markets, uses and new developments for northern hardwoods.** N.Y. Forester 19 (1) : 9-11.

Reviews the qualities of the material available in relation to uses, emphasizing the constant necessity for retaining and expanding the markets for wood in its natural form.

Simmons, Fred C.

1962. **Space age sawmill in eastern Maine.**

Northeast. Logger 10 (7) : 12-13, 34-35, illus.

Describes the equipment, installation, and operation methods that have enabled this new sawmill at Princeton, Maine, to exceed its predicted production capacity.

Simmons, Fred C.

1962. **Opportunities for marketing mill residues.**

Northeast. Logger 10 (9) : 16-17, 38-39, 44-45, illus.

Describes the various market outlets for mill residues in the Northeast, and the conditions that make it feasible for sawmills in many areas to obtain supplemental income from residues.

